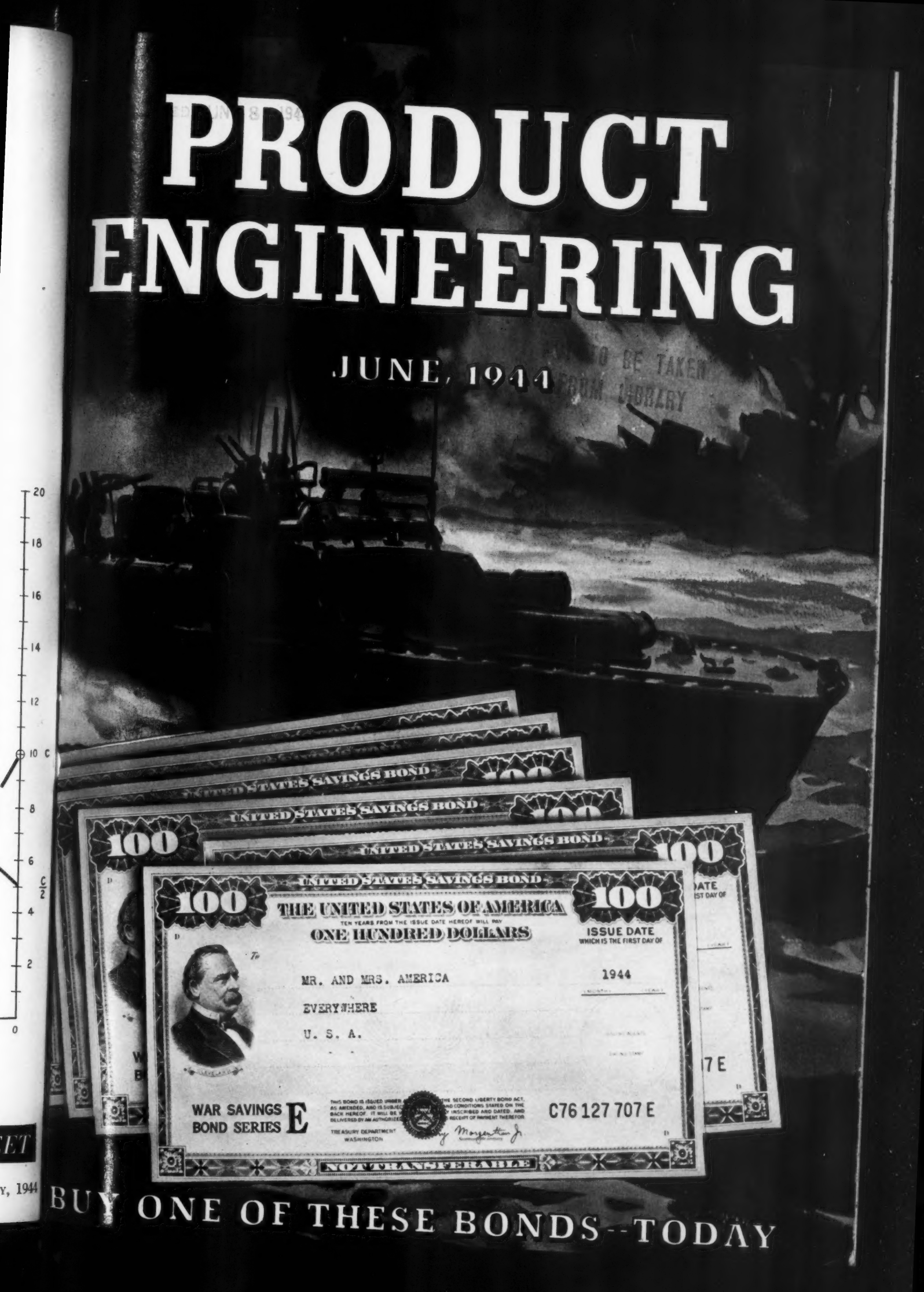
PRODUCT ENGINEERING

JUNE, 1944



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VOLUME XV — JUNE, 1944 — NUMBER 6

A New Federal Service Offered to Small Manufacturers.... 361
MAURY MAVERICK

Sheet-Steel Assemblies Economize Production..... 364
D. H. GASTON

Wartime Designs and Wartime Design News..... 368

Effect of Inertia Forces in Multicylinder Engines..... 380
MERHYLE F. SPOTTS

Spring Motors and Associated Mechanisms..... 384

Low-Pressure Laminating Adaptable to Large Parts..... 386
T. N. WILLCOX

General Considerations for Needle Bearing Applications... 389
WALTER H. KORFF

Special Insert:

Electric Controls for Present and Post-War Products.. 393

Simplified Procedure for Scaling Perspective Drawings.... 409
JOHN GONZALES AND W. P. COUSE

Knowledge of Shrinkage Aids in Design of Plastic Parts... 414
C. R. SIMMONS

Newly Developed Fuse Protects Hydraulic Lines..... 416
J. C. DE GRAAF AND JACK BASKIN

Volume of Spherical Segments..... 431
C. P. NACHOD

Lamp Dimming Rheostat Chart..... 432

Editorial 379
Industry and Societies 420
New Materials and Parts 425
Manufacturers' Publications .. 430

Subscribers may encounter delay in receiving their copies of PRODUCT ENGINEERING. Such delay is caused by wartime strain on transportation and postal systems, a situation beyond the Publisher's control.

IN THIS ISSUE

Cover Picture—PT Boat in action. Water color by Jack Coggins, courtesy of Yachting Publishing Corporation and Electric Boat Company.

Special Section: Electric Controls

The rapid progress made by science and engineering in wartime is amply demonstrated in the advances and improvements in the design of electrical control devices. A special editorial section, see pages 393 to 408, describes the construction features and fields of application for electrical devices to control starting, stopping, and varying speed of machines and equipment, also devices to control the sequence and cycling of operations and processes.

Aid for Small Plants

Work performed and planned by the Smaller War Plants Corporation to aid small business plants meet technological stumbling blocks is described by Maury Maverick, Corporation Chairman, in an article on page 361. PRODUCT ENGINEERING is pleased to present this official description of the government agency's operation and its projected plans for helping small manufacturers.

Effects of Inertia Forces In Multicylinder Engines

Continuing the discussion dealing with inertia forces in engines which was published in the May number,

"Analysis of Inertia Forces in Reciprocating Engines," M. F. Spotts, Northwestern Technological Institute, the current article, page 380, analyzes the effects of such forces in multi-cylinder engines. Equations are also derived for determining the forces resulting from gas pressure. Equations are included for determining the inertia effects solely by computation.

Low-Pressure Laminates

Production of parts or assemblies of laminated resin-impregnated fabric or paper until recently was practical only by high-pressure molding. This necessitated large enough production runs to amortize high tool and die costs. Low-pressure laminating reduces these costs considerably, making small runs of large-size units economical. See page 386 for a discussion of some of the possibilities of low-pressure laminating by T. N. Willcox, of General Electric's Plastics Department.

Hydraulic Fusing

For some time, hydraulic engineers have been discussing the possibility of hydraulic fusing, analogous to electric fusing, for sealing ruptured lines and preventing loss of fluid. Recently, a new quantity-type fuse has been developed and is now being successfully applied on military aircraft hydraulic systems. Although present applications are necessarily limited to war equipment protection, this new device promises to have wide application to fluid systems in post-war industrial designs. For a complete analysis of the new fuse, its functions and applications, turn to page 416.

Needle Bearing Problems

High load capacity and small space requirements are important advantages of needle bearings. Such bearings have certain features not found in ball or roller bearings and require special considerations in their application. In an article on page 389. Walter H. Korff, production standards engineer, Lockheed Aircraft Corporation, explains how to design needle bearing mountings, pointing out wherein they differ from other types, and summarizing the importance of various considerations that govern their selection.

Sheet-Steel Assemblies

Redesign of structural parts for fabrication by sheet-steel stamping assemblies and built-up structures has been done in the aircraft industry as in other industries to replace more expensive and time-consuming methods of production. D. H. Gaston, Consolidated Vultee Aircraft Corporation, tells of his experiences in redesign, particularly those in which furnace copper brazing is employed, on page 364. Nine redesigns represent savings of $700,000 in only one division of the company.

Scaled Perspectives

Tedious aspects of perspective drawings have been removed in a simplified procedure devised by John Gonzales, chief of graphic illustration, and W. P. Couse, supervisor, production illustration, Fleetwings Division of Kaiser Cargo, Inc. The authors, who believe that scaled perspective is the only satisfactory method of eliminating distortion in pictorial drawings of technical subjects, describe and illustrate their system on page 409. It is now in use at Fleetwings and is being taught at Drexel Institute of Technology.

Spring Motors

Spring motors, best known in their applications to clocks, watches, and toys, have many other applications and possibilities for use in larger mechanisms requiring somewhat greater power. Some of the best engineering skill has gone into the design of spring motors for phonographs in which constant speed is essential. A few examples of these designs are illustrated on pages 384 and 385 along with others having various uses.

Shrinkage in Plastics

When plastic molding was in its infancy shrinkage of the material was relatively unimportant because molds were simple, inserts were few and dimensional tolerances were rather large. As molding art progressed and plastics came into engineered uses, shrinkage properties became increasingly important. See page 414 for a discussion of the problems of plastic shrinkage and how to overcome some of the difficulties.

Volumes of Spherical Segments

Nomogram for calculating graphically the volume of a spherical segment, see page 431, prepared by C. P. Nachod & United States Signal Company.

Lamp Dimming Rheostat Chart

Chart for calculating the resistance and capacity rating of rheostats required for dimming a number of lamps connected in parallel in one circuit, see page 432. A table of rheostat ratings is included.

WHAT'S COMING

Industrial Designers

Manufacturers, particularly the smaller ones, are manifesting interest in the operations of industrial designers. PRODUCT ENGINEERING made a survey of the experience records of 24 companies which engaged outside industrial designers to assist in improving regular products and in designing new goods which would be marketable. Facts were obtained to present a clear picture of how outside industrial designers can enter a plant and consult with engineering and other executives in working out a profitable product. A brief review of design from ancient days through the years and results of the survey will be presented in an article in a forthcoming issue.

Forming Magnesium

Fabrication of magnesium presents problems not found with other metals. Data and experience on forming of this lightweight metal has not been generally available. In the forthcoming issue PRODUCT ENGINEERING will present a comprehensive analysis on the possibilities of forming magnesium alloys in a hydraulic press. The article will include data on the formation of joggles, beads, flanges, holes and bend radii, and will present charts of temperature properties and minimum bend radii. Various types of parts formed of magnesium alloys will be illustrated.

Electric Braking Methods

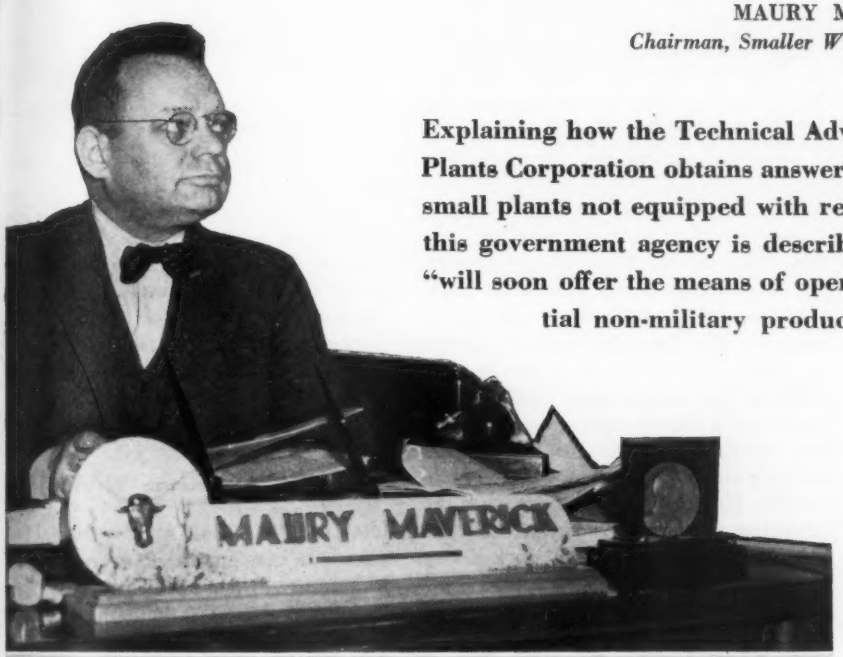
Accurate retardation and stopping of electric motors are important in many industrial drives. Some machines must be stopped instantly to prevent injury to the operating personnel. Time spent in stopping and reversing machine tools is lost time. Continuous processes may be interrupted if one element in the process is improperly timed. In the July number, E. H. Hornbarger, control engineer, Westinghouse Electric & Manufacturing Company, will discuss plugging, dynamic braking, and regenerative braking. Performance characteristics of each type with their inherent advantages and disadvantages will be fully explained and summarized in chart form.

PRODUCT ENGINEERING
JUNE, 1944

A New Federal Service Offered to Small Manufacturers

MAURY MAVERICK
Chairman, Smaller War Plants Corporation

Explaining how the Technical Advisory Service of the Smaller War Plants Corporation obtains answers to technological problems facing small plants not equipped with research laboratories. Operation of this government agency is described with an announcement that it "will soon offer the means of opening the doors to many new essential non-military products and inventive ideas."



Maury Maverick of San Antonio, Tex., graduated from Virginia Military Institute and studied law at the University of Texas. He served as a U. S. Congressman from 1935-1939, and then became Mayor of San Antonio until 1941. Mr. Maverick served as chief of State and Local Government Requirements, Office of Production Management, before assuming chairmanship of the Smaller War Plants Corporation, a government agency.

THE Germans have done much boasting about their monopoly in the manufacture of fine surgical instruments and materials. After this war, they may need something new to brag about. Through the Technical Advisory Service of Smaller War Plants Corporation, a California manufacturer was furnished with the results of world-wide research on metals best suited for plates to be used in connection with brain surgery. This manufacturer, with great talent of his own, has been helped to break ground on a new "infant industry." His plates and sutures are already helping to rebuild war casualties shattered by Axis bombs.

A Pennsylvania manufacturer of high-grade cutting tools faced complete production stoppage because a peculiar porosity developed suddenly in his non-ferrous castings. The Technical Advisory Service presented his problem to one of the nation's foremost industrial research laboratories. Laboratory experts told the manufacturer the exact quantity of an additional ingredient to add to his previous mix and suggested that he make a slight change in his timing. The suggestions were put into practice and the problem melted away.

A manufacturer of dart boards was called upon by General Arnold's Air Corps for greater production and accelerated delivery on a product used in training pilots. It was an eight color job and took hours to dry. Paint suppliers told the manufacturer he was using as much drier as his paint could absorb. The Technical Advisory Service contacted a source of counsel which suggested an entirely different method of color application using printing ink. The owner of the business, in his desperation, had been negotiating for an adjacent three-story building. Slow drying meant more space. The new process gave him a more satisfactory product and he was able to operate successfully in his own plant.

If you are a small manufacturer suffering from production headaches, or if you need research help or advice on a technical problem, we of the Smaller War Plants Corporation can probably help you quickly and without cost through this same Technical Advisory Service now available to every small manufacturer in America.

One of the basic difficulties of the small manufacturer has been inadequate research facilities to meet present day production problems. For many years small business has been starving for the want of proper technological assistance. The lack of a single ingredient

of technical information has frequently resulted in a lost or cancelled contract. The Smaller War Plants Corporation, recognizing that its job was done only when the small manufacturer had produced and delivered the goods, set up the Technical Advisory Service to fill this technological gap in simple and inexpensive fashion.

Its first mission was to help break through production bottlenecks caused by the many new managerial problems that plagued the small manufacturer when he first converted to war goods. It has helped write an exciting chapter in our national effort to speed the output of war materials and essential civilian goods. We aim to help the small manufacturer with his problems of future production readjustment as well.

Many Sources Utilized

This Technical Advisory Service is a simple thing. I visualize it as a gigantic connecting link between the small manufacturer with his day in and day out problems and the sources to the answers of his questions, "How can I do it —Where can I get it—Who does it best?" These sources include the vast treasure chest of accumulated technological information in such Government agencies, as the Bureau of Standards, Department of Commerce, and the Department of Agriculture, as well as in the engineering colleges and universities, the technical magazines and the great storehouse of non-confidential information in the laboratories of industry.

This tremendous reservoir of technological "know-how" has cost hundreds of millions of dollars to create, but the small manufacturer has been severely handicapped in obtaining even a fraction of its usefulness. But now its benefits are being so spread out that the small manufacturer is being fertilized through it. It has been like opening the flood gates of technological irrigation to those who have been furnishing more than a third of our peacetime factory employment.

The small manufacturer is a mighty important person. He pays a great deal in taxes toward the maintenance of government agencies and we hope to increase the practical usefulness of taxes to him. He is entitled to this by actual right. We are making it our business to see that small business no longer needs wither on the bough for lack of sufficient scientific assistance to maintain their competitive positions in their respective fields.

We are staffed with skilled executives. They are trained on how to canvass the best sources of scientific knowledge. Therefore we are set up to help the small manufacturer with his day in and day out problems having to do with the five "M's"—manufacturing, management, maintenance, marketing, and materials—processes and equipment.

Smaller War Plants Corporation knows the 1944 manufacturer is busy and fed up with filling out Government forms. None of this is necessary to get the benefit of the Technical Advisory Service. The small plant needing assistance simply writes a good, clear letter or calls at any one of the 112 field offices of the Smaller War Plants Corporation, describing in detail the problem involved and the objectives desired. Just as Smaller War Plants Corporation has placed liaison representatives in all Government procurement agencies to review war contracts and to intercede in behalf of the small manufacturer, so the Corporation has now placed in each of its fourteen Regional Offices experts in knowing the "know-who" and who have the best "know-how" on any submitted problems.

Let me emphasize, Smaller War Plants Corporation does not assume the role of advisor, nor do the Technical Consultants attempt to answer questions themselves. They always contact the best sources in the field of the problem, and unless authorized to do so, the name of the inquiring concern is not revealed.

When the answers are received, excerpts giving the pertinent material are sent to the inquirier in report form showing the sources of the information as well. If further help is required, the inquiring concern deals directly with the sources supplying the information.

Trade Secrets Guarded

Confidential information or trade secrets are not revealed, of course, nor does anyone expect them to be. Trade secrets form only a small fraction of the vast fund of information available.

The Service cannot promise to solve every problem submitted nor does it engage in original commercial research or testing. When such information is required, the manufacturer is directed to competent counsel, whom he can hire for a fee. The Service does not compete with, but fosters private enterprise. It endeavors to help the small manufacturer to help himself. The many letters of commendation, which the small manufacturers send in constantly, prove they are being helped.

You may be interested in the way a Technical Consultant works. Let me take a specific problem, a simple one: Here was an Eastern manufacturer who, before the war, made men's trousers. Through the efforts of Smaller War Plants Corporation he obtained a contract to make canvas cot covers and was turning out some 1,100 per day. Experience showed that the cot covers did not stand up under jungle warfare, and the War Department decided to substitute a mildew-treated canvas for the previously supplied material. Everything else was identical, but this change knocked that manufacturer's production haywire. It dropped from 1,100 to 200 per day. He began to discharge people. Then he called on the Technical Consultant, who quickly got in touch with the research director of a large company, as well as with the editor of a prominent textile magazine, to see what "know-how" they had on this problem.

This company had previously solved a similar problem for another company. The Technical Consultant got in touch with the latter who told him exactly what to do—four steps, four changes, four things that they had done to take them out of the same difficulty. The Eastern manufacturer went back to his factory, and the record shows that his production was back up in less than 40 hours.

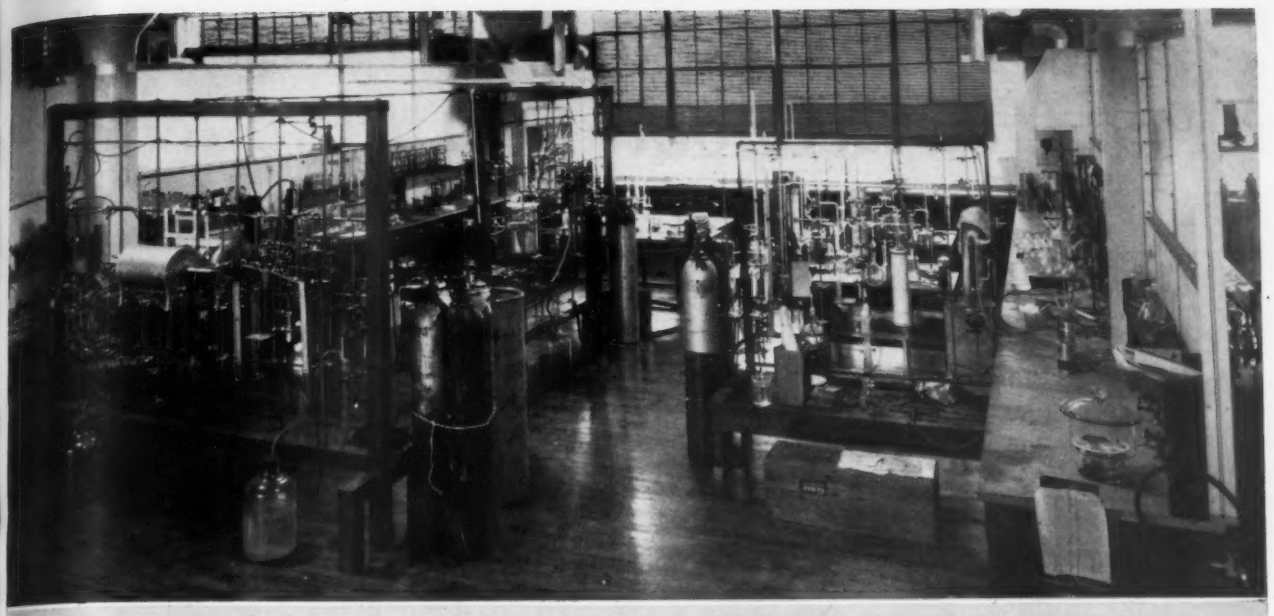
What was accomplished? Army production schedules were maintained. People were put back to work. The small manufacturer was saved from a substantial financial loss. What did the Technical Consultant do? He merely took the manufacturer by the hand and led him to competent counsel who, from experience, helped him to help himself.

Tough Problems Received

All are not such a simple problem. They run the gamut of a general "Information Please." One of the "toughies" was on the subject of urgently required technical information on hydraulic pumps. It had to do with the pattern of the pressure break-down curve between a stationary ring and a rotating disk under various conditions. There were six parts to it, but within two weeks the inquirer received reports on the subject from 17 industrial laboratories and engineering schools.

Here on short notice was produced a symposium of the nation's most expert opinion on how to break up an important industrial bottleneck. Such a swift pooling of technical knowledge represents a literally new and wartime conception of the part that a Government agency may play in our industrial society. It furnishes an unparalleled demonstration in the history of scientific and industrial cooperation in the United States.

One far Western manufacturer's labor problem was solved when he was put in touch with an improved technique of interviewing, together with a proved method of testing adaptability of new workers before employment.



Large industrial companies find the answers to technological problems in their own research laboratories, such as the one shown. The Smaller War Plants Corporation, a government agency, is interested, however, in providing the answers to smaller manufacturers who cannot afford elaborate research facilities. If a small producer is confronted with a technological problem, he can forward it to the S.W.P.C. which in turn will seek the answer from the research experience records of larger firms and other sources.

In the Denver area, as a result of technical information furnished to a number of machine shops, anodizing facilities were set up which met not only Army and Navy requirements but saved freight charges to Los Angeles and return.

A Philadelphia manufacturer was furnished with a plastic dip to bind rope ends to prevent their ravelling when used in the tropics. This acted as a substitute for a previously used dipping process and cut his production time 70 percent.

A North Texas producer seeking industrial uses for egg albumen other than for baking and candy-making was furnished with fourteen additional uses as well as with a request from a chemical manufacturer for thousands of pounds of the stuff.

In instances where the answers are furnished by the research laboratories of big business, a living demonstration is witnessed wherein big business helps little business to help itself. Small business has always wanted to help in the battle of production. It also wants to be wanted. It wants a chance to work and be useful, and inasmuch as small business makes up more than ninety-two percent of all business establishments in the United States, it is important that everything possible be done to keep this very vital source of future employment alive and aggressive. To help accomplish this, we have made this Service readily available to every small manufacturer in America, and I invite all of them to use it fully.

Assisting in patriotic and public-spirited fashion are the 65 members of our Science Advisory Committees set up in the various Regional Offices. Experts from the fields of physics; and mechanical, chemical, bio-chemical, electrical, and metallurgical engineering make up these committees. They are doing a great job furnishing part-time assistance gratis in behalf of the smaller manufacturer.

These men recognize that many large organizations have research units which often are several times the size of the whole of a small enterprise. We wish there were more of them. They have libraries and analysts devoted to a study of technical developments. Through them discoveries of great importance to the economy have been made during the war. New plastics, ceramics, light metals, textile fibers, rubber substitutes, have opened broad horizons. It is essential that small enterprise not only know the potentialities of these and other materials but how to process them. Smaller War Plants Corporation created this Technical Advisory Service to act as a clearing house for such information for small businesses. It will contact the best knowledge in universities, research institutions, and industry so that the particular problems and interests of small plants can be solved. Our program will strengthen the free-enterprise system and tend to offset to some degree the pressure toward centralization of industry.

Smaller War Plants Corporation has developed other avenues of assistance for the small manufacturer in connection with the Technical Advisory Service. We are now helping him to obtain the full usefulness of the 45,000 patents seized by the Alien Property Custodian for royalty-free licensing to American companies. In the last war there was no Smaller War Plants Corporation and the small manufacturer was pretty much the forgotten man in that respect. Not so this time.

We will soon offer the means of opening the doors to many new essential non-military products and inventive ideas which have already been submitted to various government agencies now cooperating with the military services and with Government agencies. Small business has always provided one of the nation's greatest proving grounds for new ideas and new products. It is the seed bed from which big businesses frequently grow. Like a young plant, these potentially big companies frequently require a chance to get started and through the Technical Advisory Service, we aim to see that they get something for their taxes paid. When the returning soldier and the ambitious factory workers again venture into business, we aim to assist them by keeping them properly informed on new processes, new materials, and new machinery they had better know about.

Sheet-Steel Stamping Assemblies Produce Economies in Production

D. H. GASTON
Consolidated Vultee Aircraft Corporation

Use of sheet-steel stamping assemblies and other simplifications in redesigning structural parts, especially where furnace copper brazing can be employed, have resulted in drastic savings in man-hours, faster production, and usually reductions in weight without sacrifice in strength of parts.

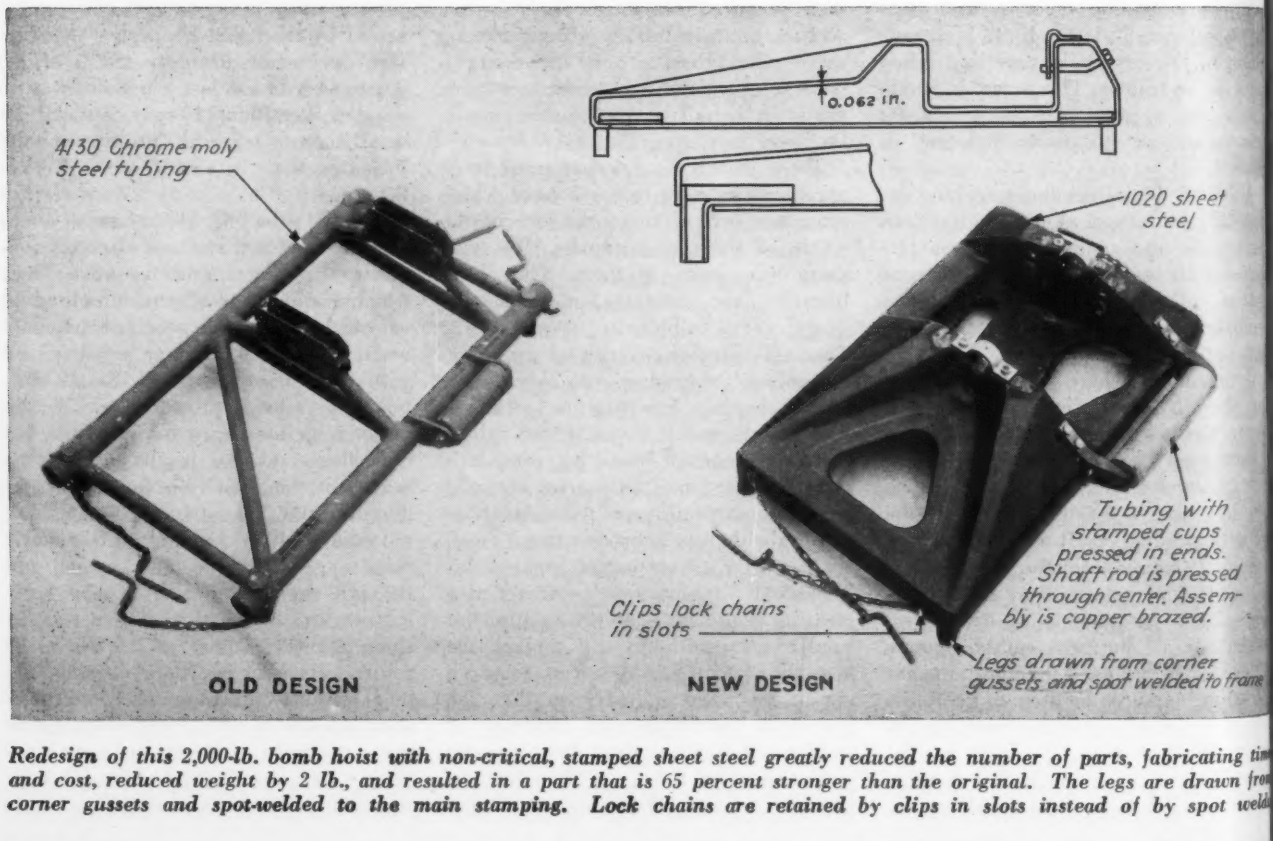
FURNACE copper brazing, which is relatively new to the aircraft industry, has made it advantageous to redesign a number of aircraft parts for sheet-steel stamping assemblies and built-up structures. These redesigns replace machined forgings in both aluminum and steel, welded parts, castings, extruded aluminum shapes that require machining, and other more time-consuming methods of fabrication. Nine of the redesigns illustrated herewith represent cost savings of $700,000 at the San Diego division of Consolidated Vultee Aircraft Corporation alone as a result of drastic reductions in man-hours. Weight was equalled or reduced in every instance.

Although the application of stampings shows greatest economy on high volume items, whether for aircraft or any other structure, in some instances the tooling cost was justified even when only one part per plane was required. Only low alloy steels such as 4130 and low carbon steels such as 1010 and 1020 are recommended for aircraft parts.

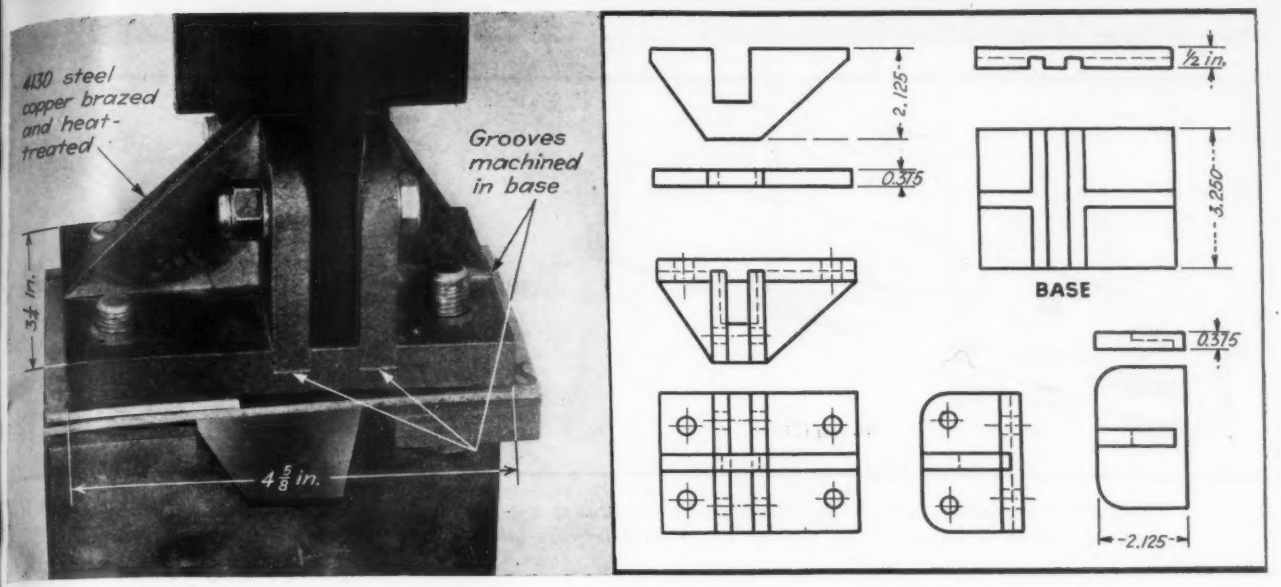
Furnace copper brazing has one outstanding advantage over all other types of silver solder, silver braze and like methods in these applications: Heat-treatment can be used after brazing without disturbing the joint. However, since grain growth occurs in the brazing furnace, heat-treatment is specified on all furnace brazed parts, even if only the annealed condition is required. Customary magnetic inspection, which is required after welding, is unnecessary when furnace copper brazing is used.

Three classes of inspection for copper brazed joints have been established:

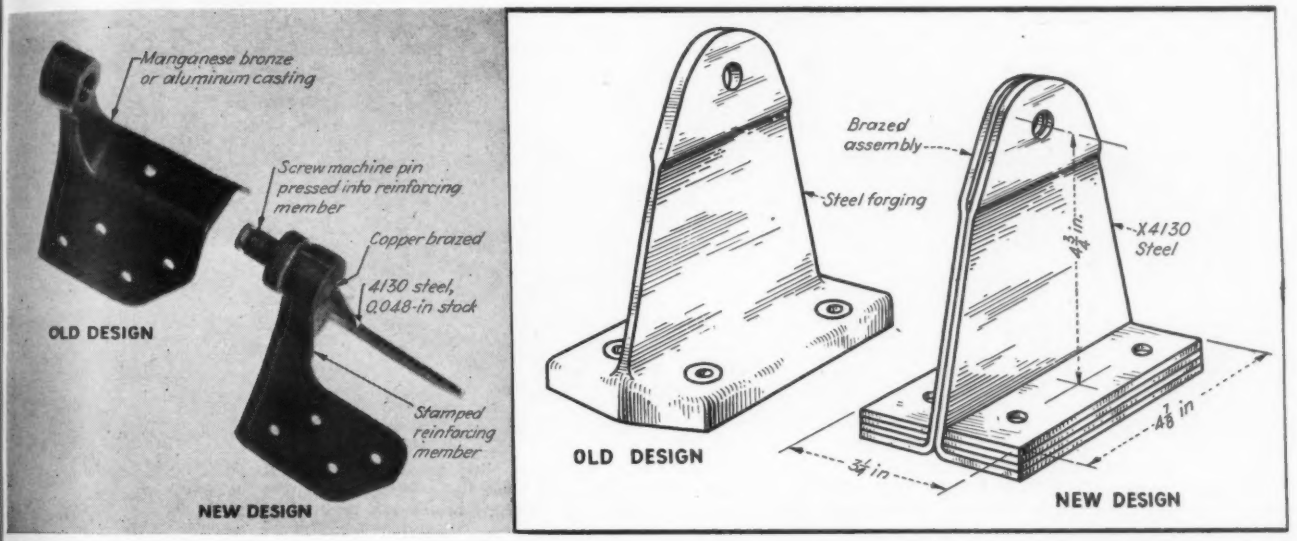
Class I inspection pertains to hidden joints, or those in which the edges of the braze are not visible, in highly stressed parts. This inspection requires sectioning a sample from each produc-


4130 Chrome moly steel tubing
0.062 in.
1020 sheet steel
Tubing with stamped cups pressed in ends. Shaft rod is pressed through center. Assembly is copper brazed.
Clips lock chains in slots
Legs drawn from corner gussets and spot welded to frame
OLD DESIGN
NEW DESIGN

Redesign of this 2,000-lb. bomb hoist with non-critical, stamped sheet steel greatly reduced the number of parts, fabricating time and cost, reduced weight by 2 lb., and resulted in a part that is 65 percent stronger than the original. The legs are drawn from corner gussets and spot-welded to the main stamping. Lock chains are retained by clips in slots instead of by spot weld



Bomb shackle design with 4 pieces of plate fitted together like an egg crate replaces a complicated machined forging. Brazed joints held a test load of 30,000 lb., which stripped bolt threads.



(Left) Bomb door roller bracket was formerly a manganese bronze or aluminum alloy casting, tapped for a special bolt and nut. Redesigned in 4130 sheet steel, the bolt was replaced by a pin and the assembly copper brazed. A roller, not shown, is held in place on pin by a snap ring. The stamped bracket weighs no more than the aluminum casting, yet has the strength of the manganese bronze casting. (Right) Nine simple sheet-metal parts, tack-welded together and copper brazed, make as satisfactory a bracket as the former forging, which was more difficult to produce. Center of base is cut out in same design.

tion run. A visual inspection before brazing checks the position of the copper and assures that there is metal interference in the joint.

Class II inspection applies to visible joints that are highly stressed. Visual inspection is made before brazing for location of the copper and to assure proper metal interference in the joint, and after brazing to determine the flow of copper through the joint.

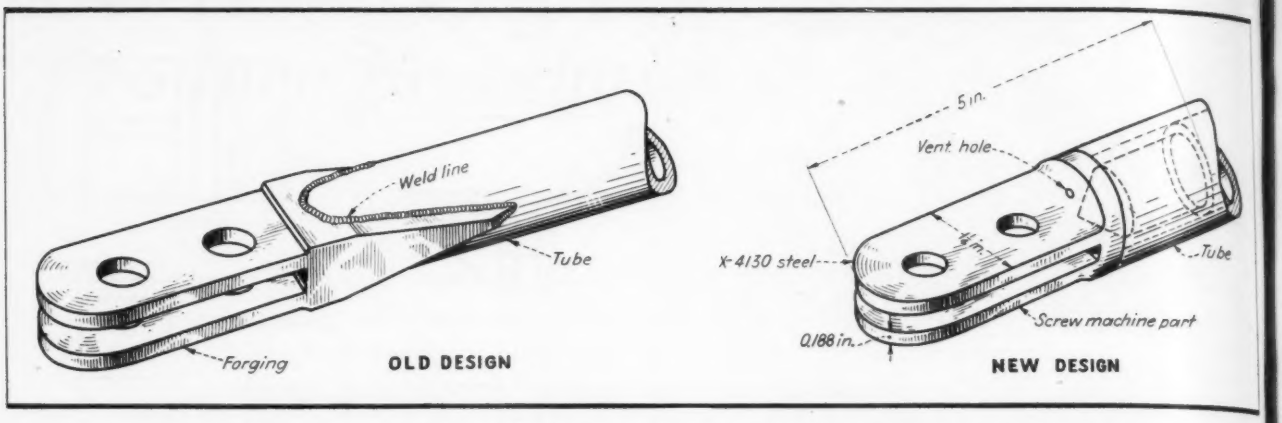
Class III applies to visible joints that are not stressed or just slightly stressed. Inspection is the same as for Class II.

Light press fits designed for shear only are specified for all joints. This leaves sufficient space to be filled by molten copper, which is pulled inward by capillary attraction. Army specifications permit a design allowable of 10,000 lb. per sq. in. in shear on secondary structure and non-structural applications only. Separate approval is necessary from the Air Corps for each application to a primary structure.

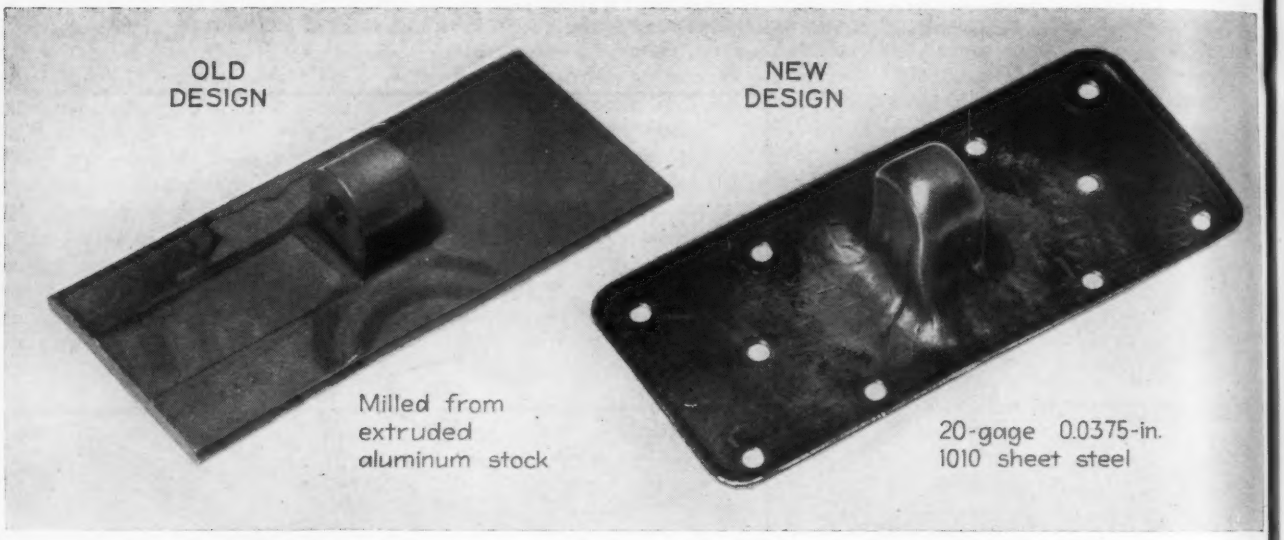
Although a great deal has been written on stamping design for many types of applications, the surface has merely been scratched in this field. More consideration should be given by the designer to the uses of stamping and automatic screw machine parts joined by means of furnace copper brazing. Similar reductions in weight and man-hours can be made on both wartime and peacetime products.

For additional information of brazed joints see the following articles in PRODUCT ENGINEERING: "Joints Brazed by Induction Heating," Feb. 1943, p. 102; "Redesigning for Furnace Brazing," Oct. and Nov. 1940, pp. 448 and 518; "Furnace Brazed Joints," Apr. and Aug. 1939, pp. 166 and 341.

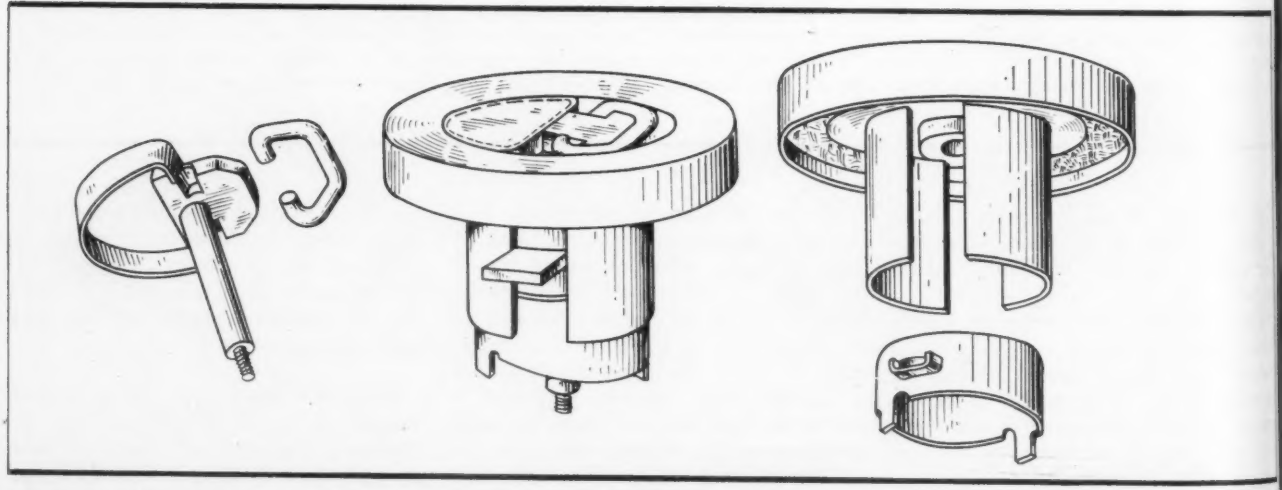
Sheet-Steel Assemblies (continued)



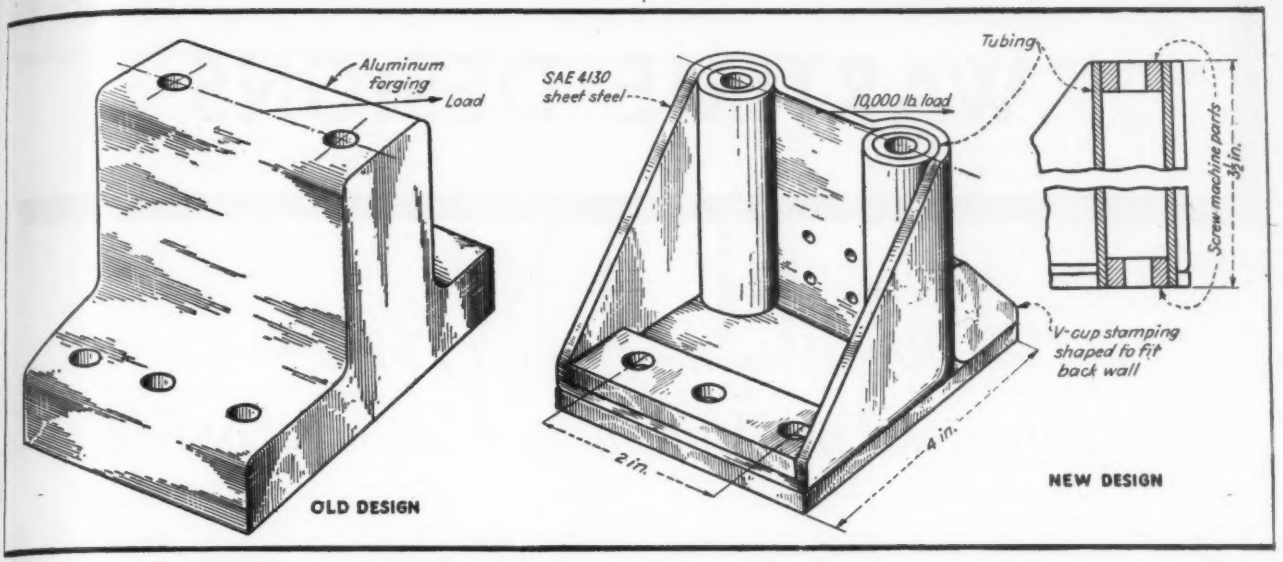
Tubular strut production is greatly simplified by substituting a screw machine part for a forging and furnace brazing instead of welding. The new part is pressed into the tube. Vent hole is closed after heat-treating.



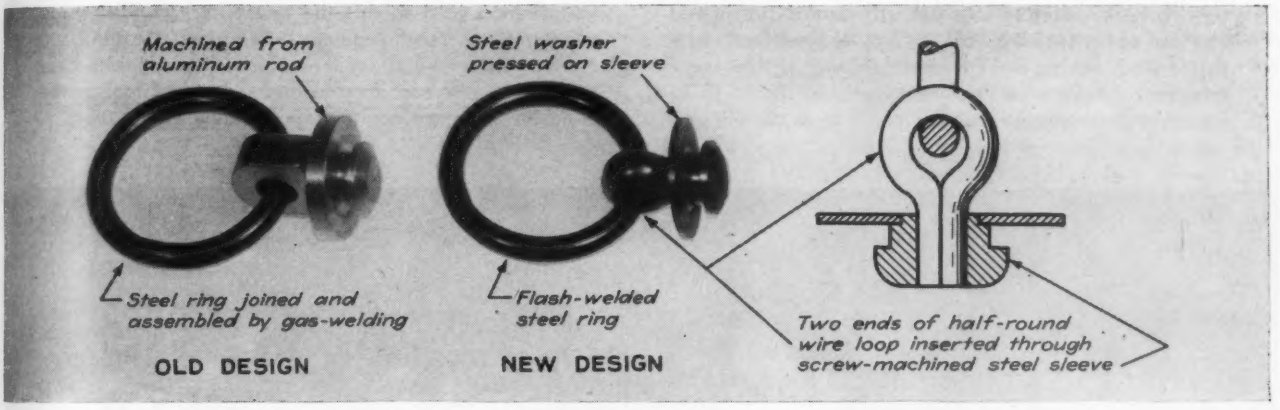
An attachment fitting formed in 20-gage sheet steel performs the same job as one formerly made by straddle milling extruded aluminum stock. An inserted block will give added strength.



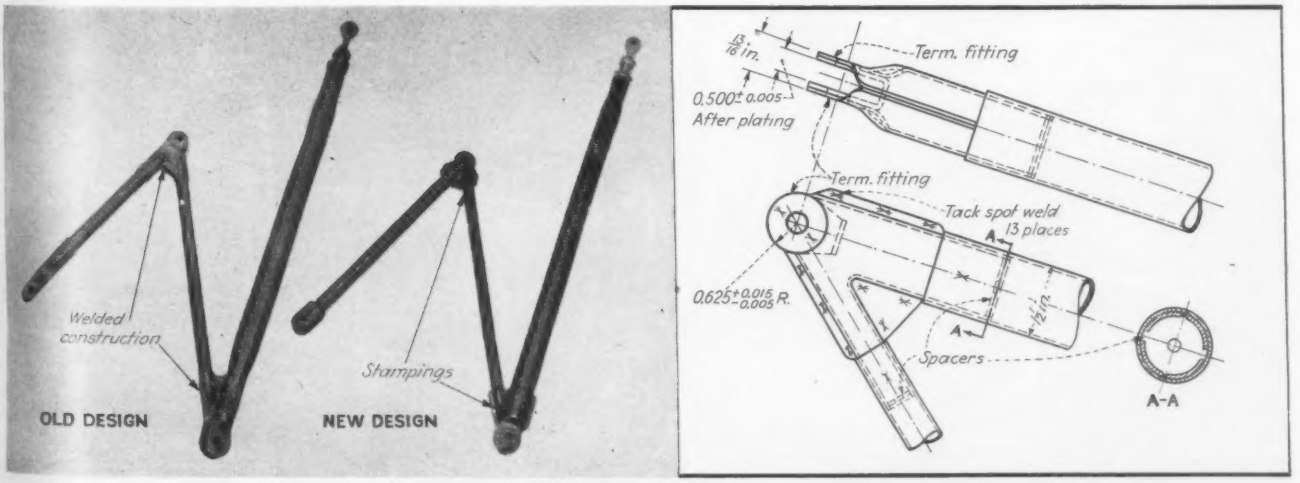
Fuel cell filler cap is an assembly of 10 stampings. Detail at left includes handle, held loosely by heavy piece of steel blanked out to accommodate it and a shaft. The fourth member, a light steel stamping, is tack welded, then the assembly is furnace brazed. Center detail is the cap proper with two guide members attached by copper brazing. Before brazing, guides are retained in cap by ears. Detail at right is cam collar, which consists of 3 stampings tack welded and copper brazed.



Composite sheet-steel stampings, tubing and screw machine parts, joined by furnace brazing, make a bracket weighing half as much as the aluminum forging that it replaced.


Machined from aluminum rod
Steel ring joined and assembled by gas-welding
OLD DESIGN
Steel washer pressed on sleeve
Flash-welded steel ring
NEW DESIGN
Two ends of half-round wire loop inserted through screw-machined steel sleeve

Redesign of this cargo tie-down ring permitted use of heat-treatment, formerly impossible after assembly. Although now made of four parts instead of two, production is simpler, faster and less expensive.

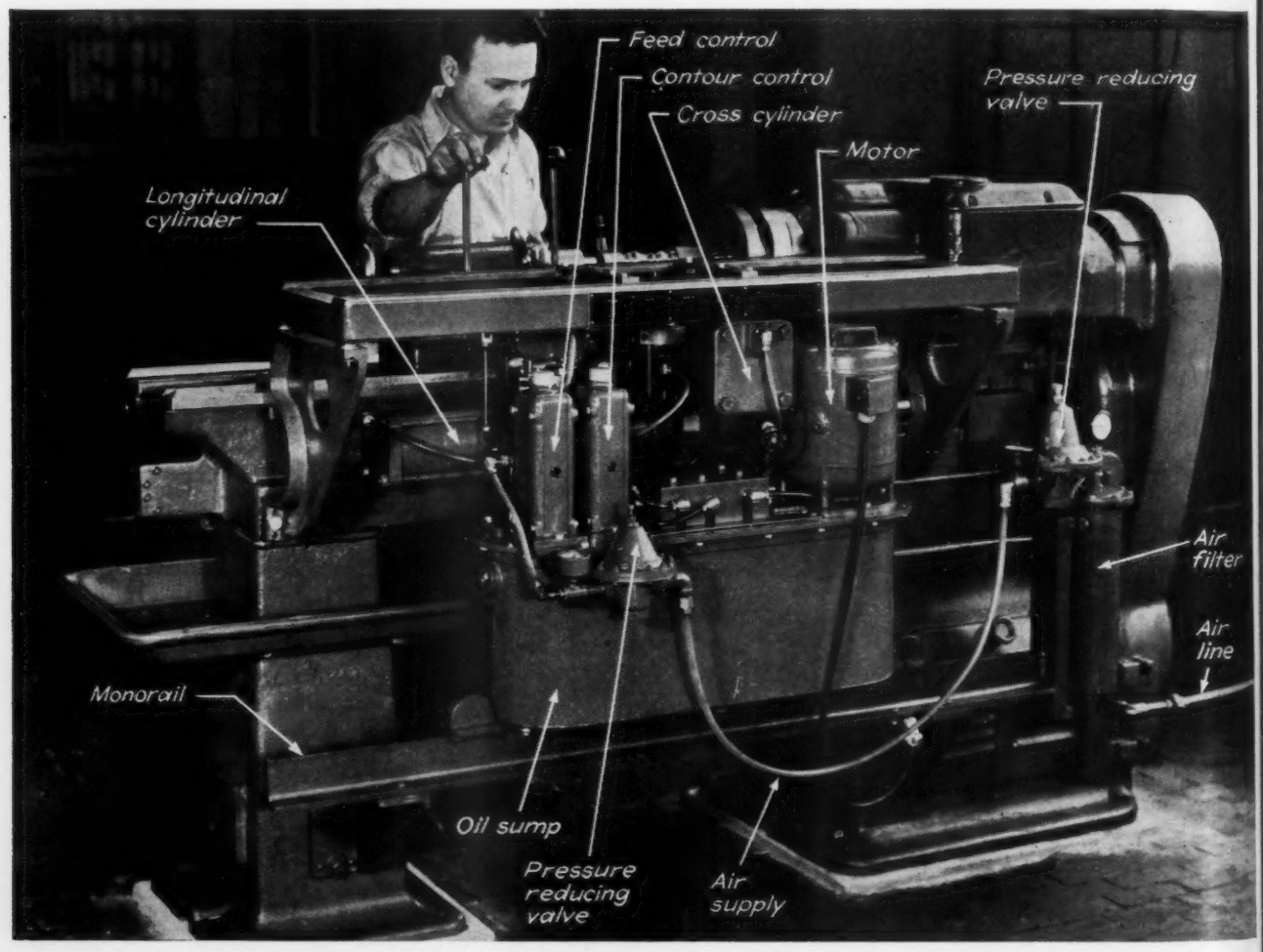


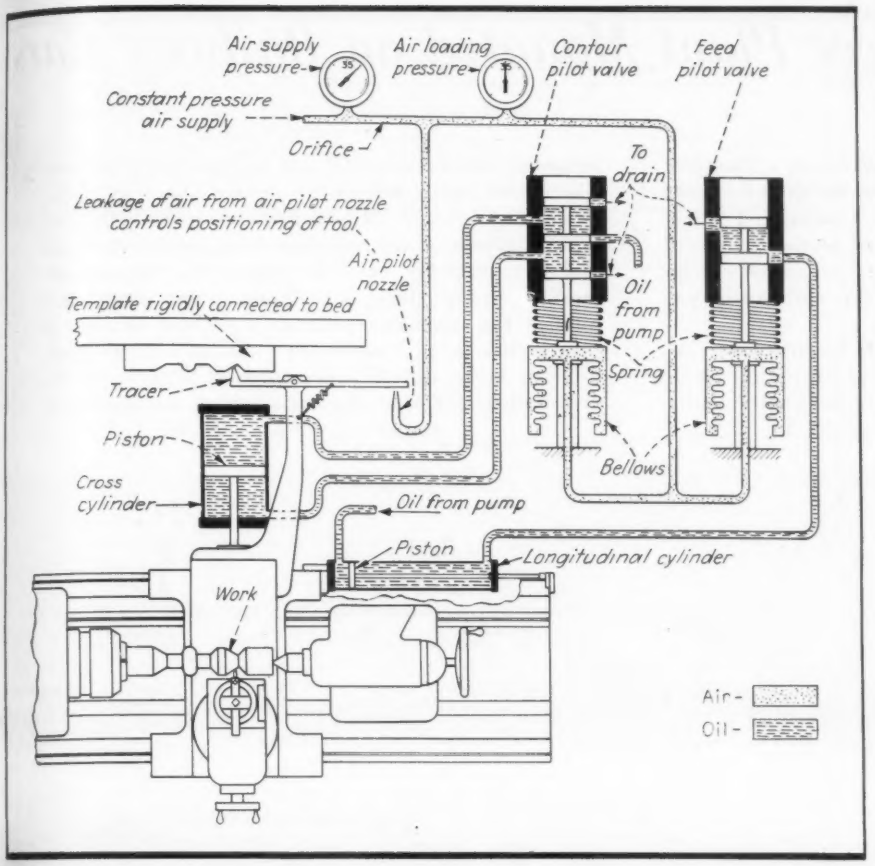
An outstanding substitution of stampings for machined forgings, and copper brazing for welding. Man-hours were greatly reduced. Washers separate the two mating stampings and hold the diameter to size inside the tube, thus permitting a pinch trim on stampings where they enter the tube and avoiding accurate control of size of stampings. Washers are retained by lugs fitting into slots in stampings. Attachment holes are reamed to the exact 3-point dimensions after heat-treatment.

WARTIME DESIGNS

Regulation of Fluid Flows Eliminates Lost Motion in Contour Control

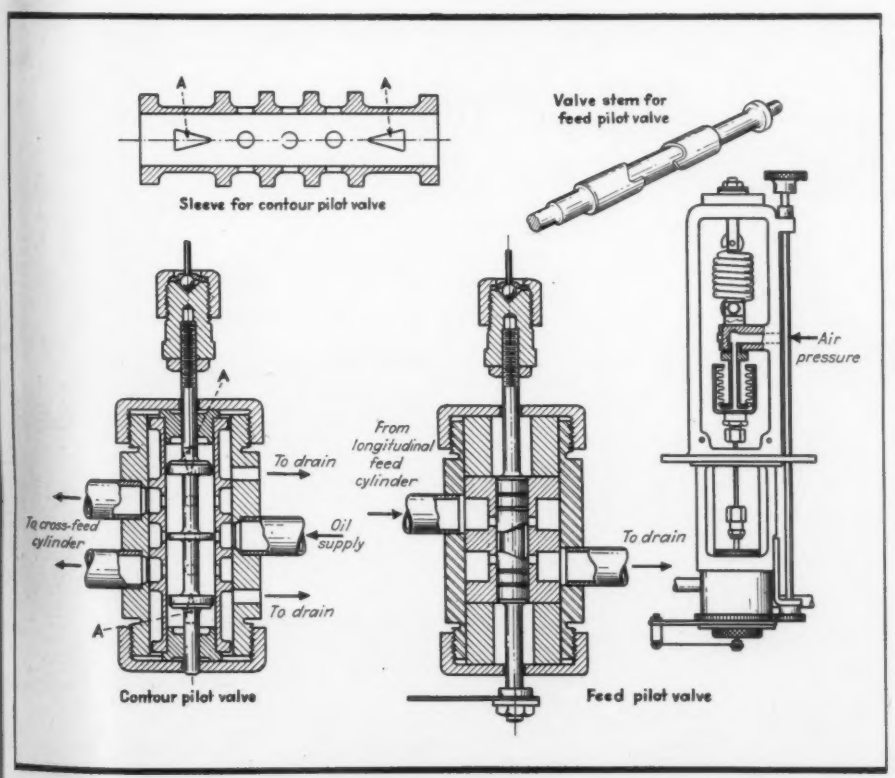
PNEUMATIC and hydraulic systems are combined in the contour control devised by the Bailey Meter Company, Cleveland, for application to machine tools, particularly engine lathes, turret lathes and boring mills. The self-powered, self-contained attachment utilizes the principle of the air measuring gage to regulate the hydraulic circuits that actually power the in-and-out feed of the toolslide and the longitudinal feed of the carriage. A spring-loaded tracer follows a thin metal template. Changes in contour cause the tracer to increase or decrease the leakage of air from the air-pilot nozzle. Since the pneumatic system is always under pressure, 35 lb. is the "neutral," commensurate changes take place in the back pressure that controls both the contour pilot valve and the feed pilot valve. The hydraulic systems respond within a few thousandths of a second, automatically varying the cross feed and the longitudinal feed to suit the momentary condition encountered, thereby producing "stepless" turning. In other words, in-and-out cross feed and longitudinal feed rate are so coordinated that spacing of tool marks is uniform, regardless of shape or slope of contour.





Contour control operation is shown schematically. Assuming the tracer is following a rise on the template, the air gap increases and back pressure in the system falls below neutral. The back pressure operates mutually upon the contour pilot valve and the feed pilot valve. Contour pilot valve bellows expand and spring pressure causes the oil-pilot stem to move downward. The lower port opens to drain, oil from the pump enters the central port, flows to the rear of the cross-feed piston, causing it to move forward. The toolslide feeds out from the work centerline until the normal air gap is reached. At this point the contour pilot valve completes return to its normal position, locking the cross-slide in fixed position by applying hydraulic pressure equally to both sides of the cross-feed cylinder. Under conditions of straight turning, both ports of the feed pilot valve are partially open, so that longitudinal feed coincides with the preset rate of drain from the rear of the power cylinder. But as the pressure on the bellows is decreased by the above conditions, the drain port is correspondingly closed and the feed rate decreases. If a square shoulder is being machined, the drain port is entirely closed.

If the tracer were descending into a recess in the template, the air back pressure would increase, oil would be admitted to the opposite side of the cross-feed cylinder, causing the tool to feed inward. But the longitudinal feed rate would again be throttled.



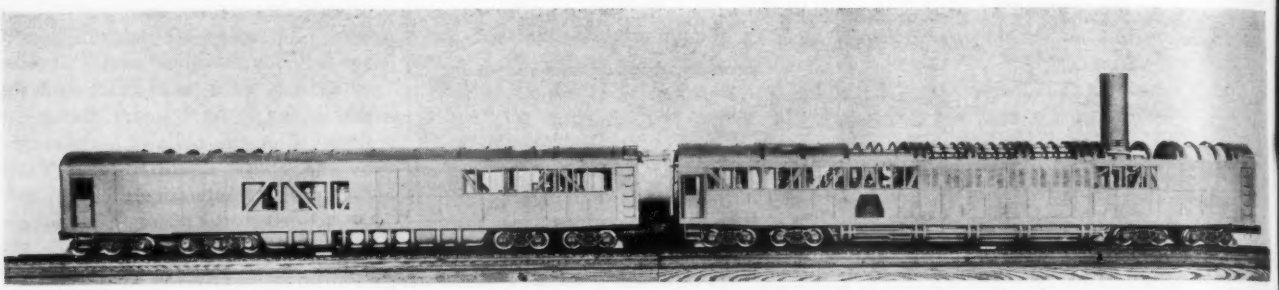
Triangular ports *A* **in the** sleeve of the contour pilot valve act like weirs to meter the rate of flow to drain when uncovered by the oil stem. If the surface being machined is a slow taper, only a small portion of one port will be uncovered, and a steady cross-feed in small increments per unit of time will result. If the template calls for machining a square shoulder, however, the drain through the port becomes a maximum. Oil between the outer lands of the stem and the guides provided at the top and bottom of the pilot valve body, produces a dashpot action which prevents fluttering of the pilot stem, bellows and spring assembly.

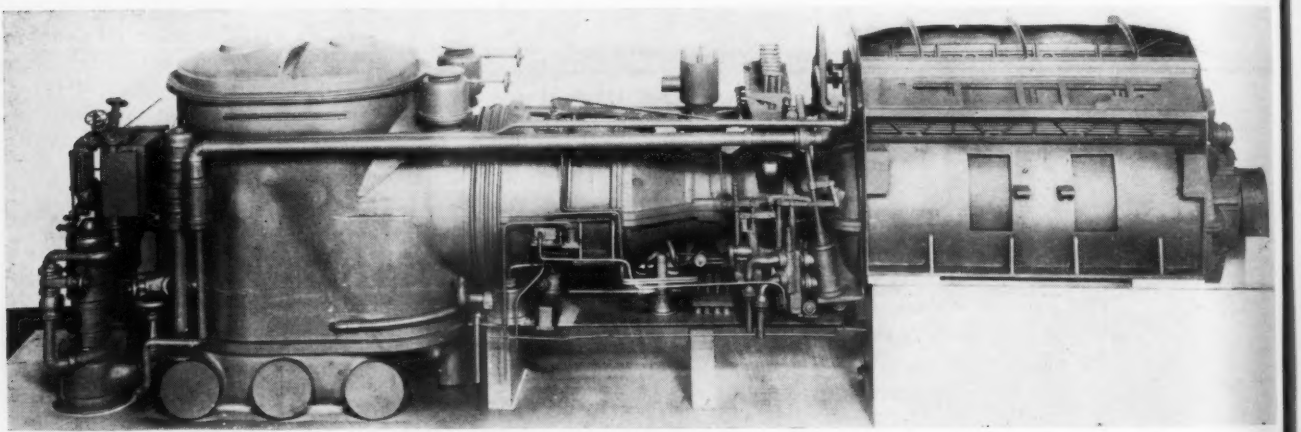
Two forms of valve stem can be used in the longitudinal feed pilot valve. Stem illustrated has two opposed cam-like recesses. Each recess has two lobes, 180 deg. apart, which are representations of a thread. By positioning the pilot stem radially by a flexible cable and thumbwheel working through gearing, it is possible to preset the rate of flow in close increments.

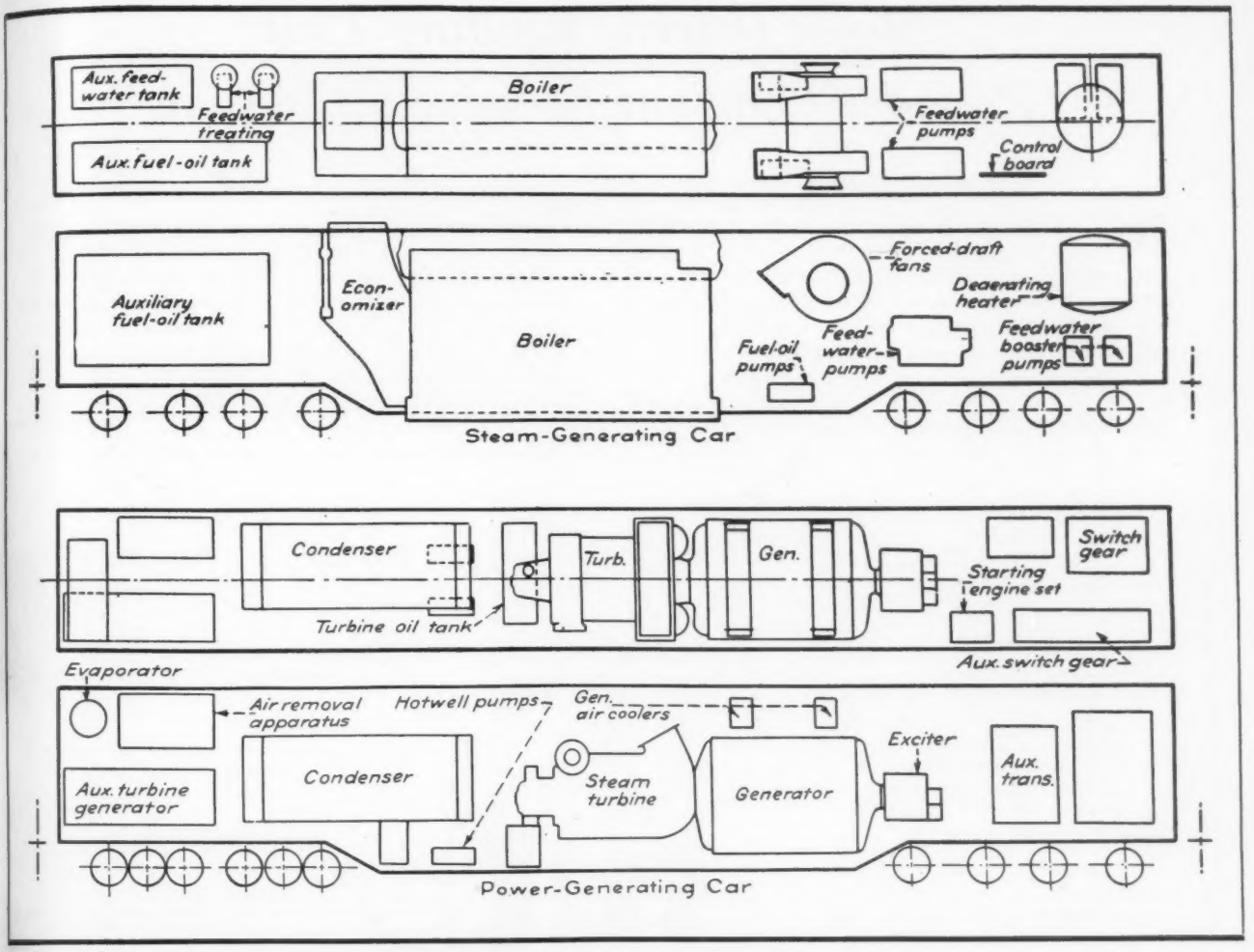
10,000 KW. Power Plant Mounted on Railway Cars

SIX specially built railway cars house a complete steam turbine generating system developed for the U. S. Navy by the General Electric Company. The mobile plant was initiated and financed by the Bureau of Yards and Docks. Unit is not self-propelled but can be hauled at speeds up to 40 mi. per hr. and can be put into service within 24 hr. of arrival.

In developing the design, General Electric made extensive use of models built to exact scale. Photo shows the turbine and boiler cars as finally built; below are shown the model cars used to determine location of the equipment in the limited space available. Train is made up in six principal units: The boiler car, turbine generator car, switchgear car, transformer car and two accessory cars carrying parts such as collapsible smoke stack, circulating water pump and piping, and auxiliary pumps. Combined length of cars is 405 feet. Transformer included with the unit provides other voltage corresponding to those of the distribution system at any naval shore establishment.





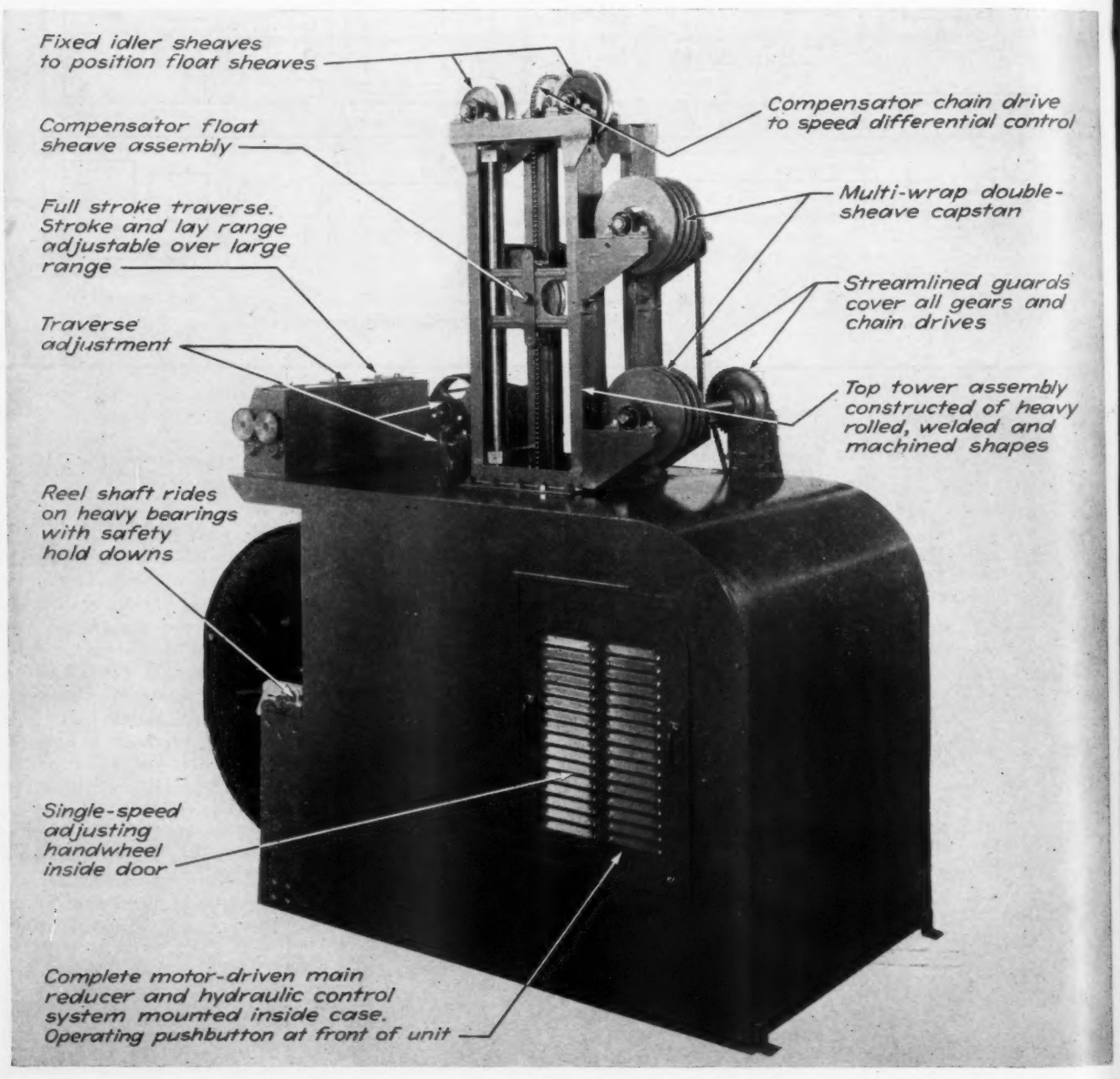


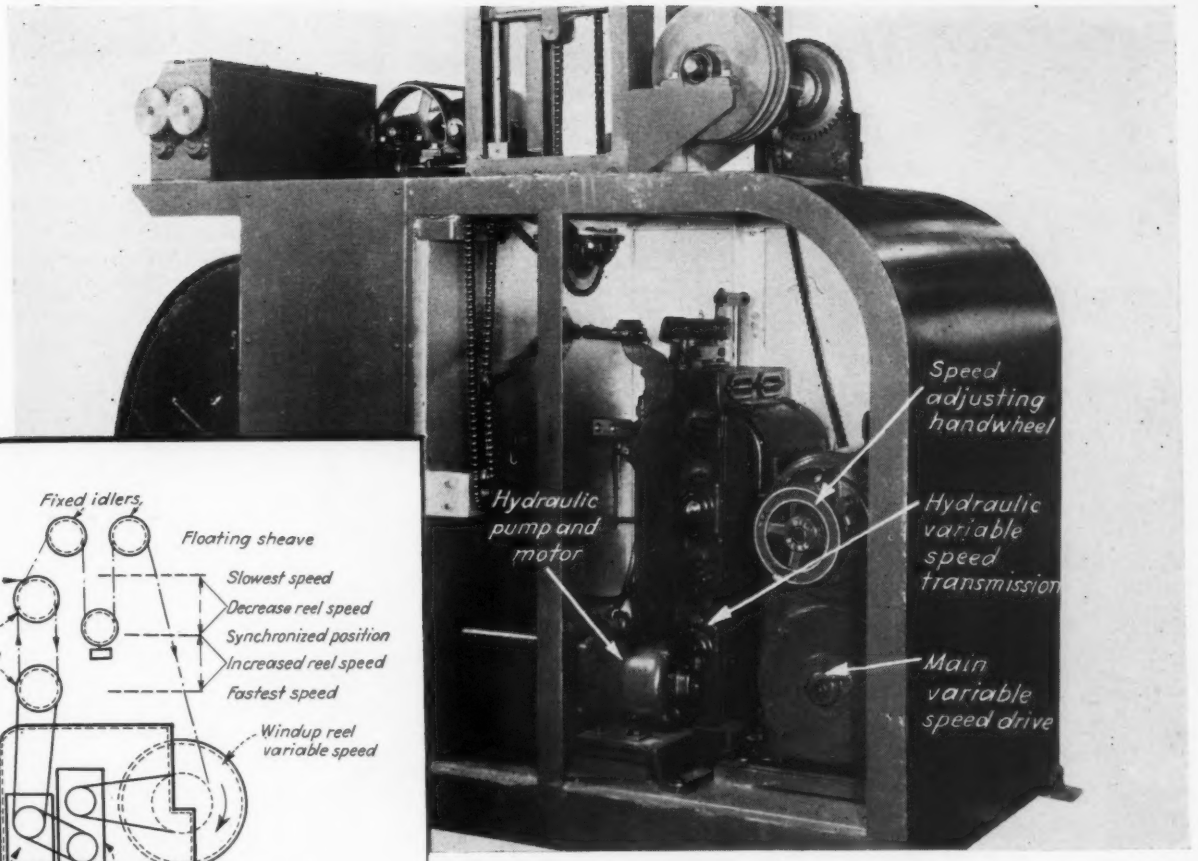
Model of the 350 kw. auxiliary set which supplies starting power for main turbine in place at the left. Construction of model parallels construction of the drop-frame type. Turbine car is carried on ten axles; boiler car on eight axles. Each car weighs about 200 tons. Bunker C fuel oil is used. Mobile unit carries enough oil for two hours of operation before tank cars are connected. The 3,600 r.p.m. generators furnish 13,800 volts of 60-cycle, three-phase power. The sketches above show schematic layout of boiler and turbine cars with approximate location of units; as determined when project was first initiated.

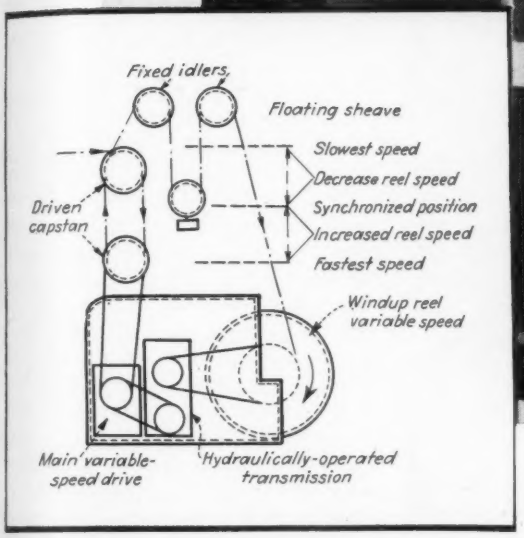
Motor-Driven Winding Unit Provides Constant Speed and Tension

DEVELOPED by the Industrial Oven Engineering Company, under the supervision of C. A. Litzler, chief engineer, this self-contained windup machine consists of a driven capstan, a hydraulically-operated variable-speed transmission, a weighted float roll stand and a main variable-speed mechanical drive.

Machine housing is heavy steel plate and cast members bolted to a structural steel frame. Stationery sheaves on float sheave stand are mounted on steel shafts riding in bronze-bushed hubs. Single-groove float sheave, fitted into a cast-iron floating frame, is connected by roller chain to the control handle of the hydraulic operating valve. Windup machine is driven by variable-speed reducer located inside of housing. Speed range is four to one. Output shaft of variable-speed reducer is connected to input shaft of main reel transmission unit through precision roller chain. Capstan assembly consists of heavy base plate and frame supporting two four-groove driving sheaves mounted in tandem units driven in synchronism with roller chain.


Fixed idler sheaves to position float sheaves
Compensator float sheave assembly
Full stroke traverse. Stroke and lay range adjustable over large range
Traverse adjustment
Reel shaft rides on heavy bearings with safety hold downs
Single-speed adjusting handwheel inside door
Complete motor-driven main reducer and hydraulic control system mounted inside case. Operating pushbutton at front of unit
Compensator chain drive to speed differential control
Multi-wrap double-sheave capstan
Streamlined guards cover all gears and chain drives
Top tower assembly constructed of heavy rolled, welded and machined shapes

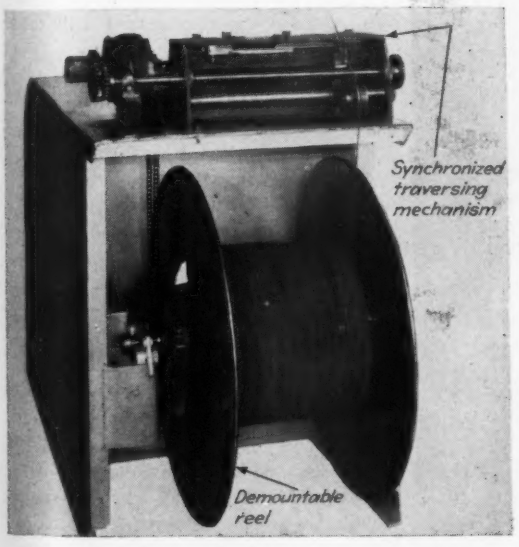




Operation: From the output of the main variable-speed unit, one power takeoff drives a capstan, while another drives the hydraulically compensating mechanical speed transmission unit that directly controls the windup speed of the reel in direct ratio to the wire diameter. The hydro-mechanical transmission system is a Reeves cone-pulley type having a block-type endless belt transmitting power from the input to the output shaft. Hydraulic cone shifters change the output speed of this transmission in definite ratio to wire speed. The hydraulic shifter is self-contained and consists of a small constant-pressure, constant-volume hydraulic pump operating a two-way hydraulic cylinder through a special four-way operating valve built directly into the transmission unit and equipped with an adjustable operating handle. Varying the position of this handle from a mean setting increases or decreases the output speed in infinite increments.

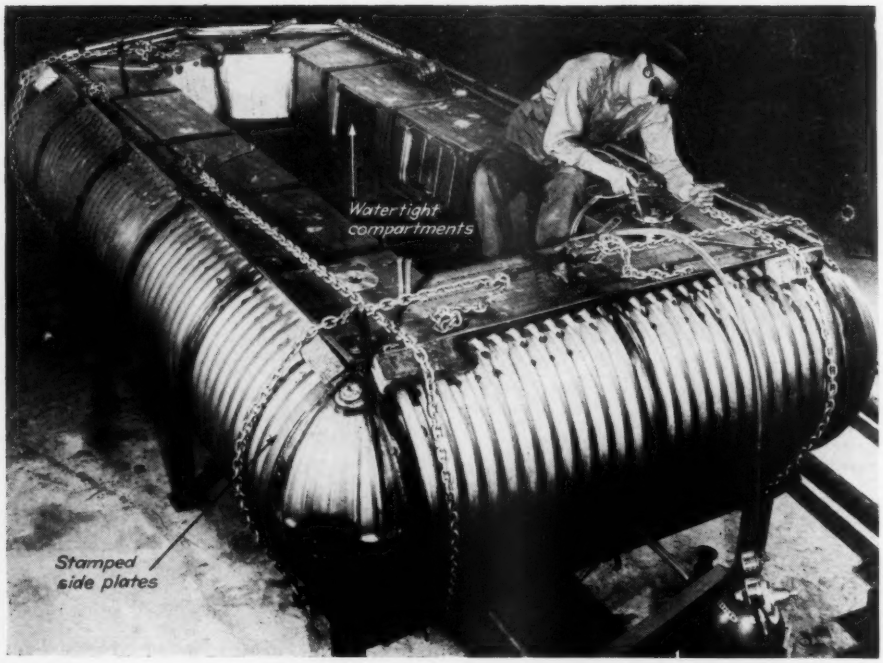
The compensator is an idler sheave free to move up and down in response to wire tension. The driven capstan, a positive drive mechanism, delivers the wire at constant speed to the float roll. If the reel is winding the wire at the same speed as the capstan delivering it, no change in the float roll condition is encountered. As the tension on the wire increases, the float roll moves up. Suitable reversed linkages then depress the operating lever and slow the output speeds of the windup reel to a point where the reel speed, regardless of diameter change, is running at wire speed.

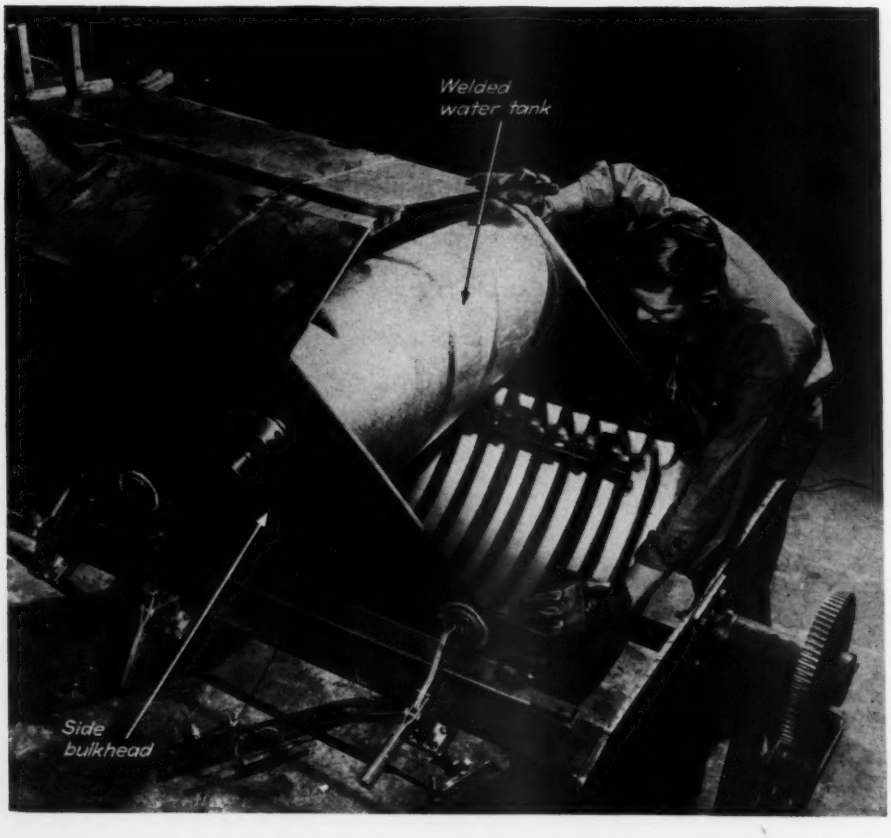
As reel diameter gradually builds up, the float roll, by its definite tendency to move in direct response to tension change reduces the reel speed. If reel velocity is slower, the tension in the wire decreases and the float roll drops. This actuates the control lever on the hydraulic equipment and speeds the reel to the wire speed. By changing the weight on the floating sheave, tension can be varied from a few ounces to many pounds.



Large diameter traverse screw is driven by power takeoff from main reel drive transmission output. Traverse lay is adjustable through a 20 to 1 range. Reel shaft is constructed of machined steel and is equipped with driving gear, driving dog arm and set collars for positioning in self-locking bearings. These cast-iron bearings are equipped with snap-lock covers to hold shaft in place during machine operation.

All-Metal Life Rafts Incorporate 19 Airtight Compartments





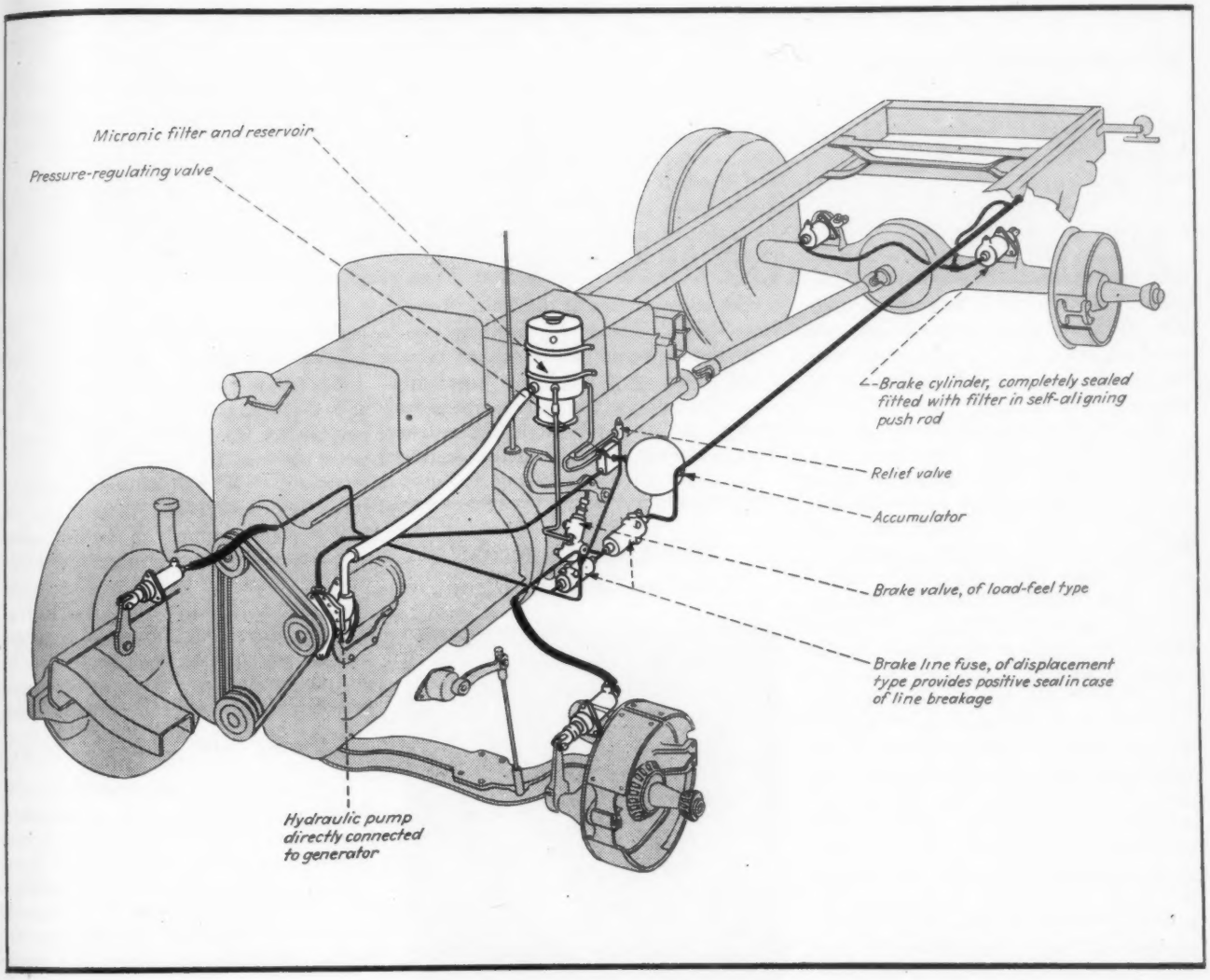
NEW compartmented rafts, produced by Weber Showcase Company, always float topside-up, since bottom and top are alike. Made of 16-gage cold-rolled steel, each raft is separated into 19 air-tight compartments, plus two airtight water tanks. Food and equipment are stored in four compartments near the center, and are reached through large openings in the side of the well deck. The openings are bolted closed.

Manufactured for the U. S. Maritime Commission, and inspected for strength and safety by the U. S. Coast Guard, the rafts weigh 2,425 lb. empty, and can carry 20 men weighing about 3,400 lb., plus 1,055 lb. of equpiment, representing a total weight of 6,880 lb. Stringent design specifications were laid down by government agencies for the proposed rafts. The rafts, of cockpit or well-deck type, had to be either reversible or self-righting, and if reversible the equipment must be available from either side; each occupant must have four square feet or more of room; at least 15 airtight compartments were to be provided; enough space was required for four men to handle 10-ft. bars without interference by other passengers, and the raft had to withstand a vertical drop of 45 feet into water without springing leaks.

Seat sections are formed and reinforced with a corrugated stiffening member. These stiffeners, spot-welded to the side of the seat, take the impact of a long, flat drop, without buckling or breaking. Drain flanges are pressed on by the induction heating method. These normally are pressed on in 31 sec. with 20 kw. of heat, on 10,000-cycle electric current. Drain flanges are silver brazed to their seats, instead of being gasketed, to insure permanent sealing.

Floor sections are pre-fabricated. Water tanks, made of 16-gage cold-rolled steel plates 33x45 in., are seam-welded to tubular shape. Heads, formed by stamping, are fastened by a rotary seam-welding. Raft is rust-proofed by treatment in Parko solution for 30 min. under a temperature of 200 deg. F., after which it is thoroughly rinsed in cold water. Following a short rinse in chromic acid at 190 deg. and second draining, drying is done under infra-red lamps. Then the raft is dipped in a tank of zinc chromate primer, and again drained, then sprayed with two coats of Navy gray synthetic baking enamel. Finish is dried by infra-red lamps.

Integrated Hydraulic Braking System Developed for Post-War Truck and Bus Applications


Micronic filter and reservoir
Pressure-regulating valve
Brake cylinder, completely sealed fitted with filter in self-aligning push rod
Relief valve
Accumulator
Brake valve, of load-feel type
Brake line fuse, of displacement type provides positive seal in case of line breakage
Hydraulic pump directly connected to generator

POST-WAR product developing at Aircraft Accessories Corporation aims at capitalizing on wartime experience in the design and development of control systems for military aircraft. Plans are to develop hydraulic, air, vacuum and electric controls for use in the automotive, marine and industrial fields. Outstanding example of the program is the closed hydraulic braking system for trucks and buses similar to the braking methods used on aircraft.

Hydraulic pressure is supplied by a small pump directly connected to the generator. System reservoir is a cylindrical sheet-metal assembly incorporating a large micronic element in the suction line as an integral part. A single bolt is removed to replace filter element. A hydraulic fuse of the displacement type is installed adjacent to each brake valve. In case of line or hose breakage, the fuse governing the affected pair of wheels provides a positive seal which prevents the loss of hydraulic fluid. Thus braking power is maintained on the other pair of wheels.

Two-Dial Rotary Timer Has 896 Contacts

TWO CONCENTRIC RINGS having 224 contact points each are furnished on each dial in a new two-dial process timer developed by General Electric Switchgear Division. Rotating contact arms are geared to a single shaft and can be driven through a clutch by a synchronous motor and adjustable gear train, or can be operated independently by separate motors. A spare motor and a handwheel for operating the unit manually are also available. The circuit to the segments is made and broken through an auxiliary switch, not at the segments, and the unit handles control circuits of 10 amperes, 125 volts. Flexible jumpers connect the segments and terminal board. The equipment is inclosed in a compact steel housing.

WARTIME DESIGN NEWS

Weapons Development

However many new weapons and refinements of old weapons have been held secret for the invasion of Europe, the stream of new devices and applications of and to United Nations arms continues in full flood.

Although aircraft appear to lead in the developments—and quite possibly actually do lead by a substantial margin—land and sea weapons are not standing pat on the models which won the North African and Sicilian campaigns.

One of the most spectacular of the recent redesign jobs was that of a 75-mm. cannon which could be fired safely from an airplane (PRODUCT ENGINEERING, Jan., 1944, page 18.), but this job has been redesigned again to give the same plane, the North American B-25 "Billy Mitchell" medium bomber, more machine-gun firepower than the Flying Fortresses were equipped with at least until introduction of the "chin turret" some months ago. The first cannon-firing Mitchells had two machine guns mounted in the redesigned nose above the cannon. Today, the B-25 sports four .50 caliber machine guns in place of the earlier two, mounts four more .50's in four streamlined mounts two on each side of the fuselage below the flight deck, for a total of eight machine guns and a cannon, all fixed, firing forward. Two waist gunners on either side of the ship man one .50 caliber machine gun apiece, and the top turret gunner and tail turret gunner each have a pair .50's, of which the top turret guns can be fired forward. This is firepower undreamed of by any but the most fanatical air and ordnance officers on Pearl Harbor day, when our fighters mounted four .30 caliber machine guns on an average.

Other Bombers Bristle

The B-25 is not the only extra-heavily armed plane by any means. The new Martin B-26 Marauder mounts twelve machine guns, all .50 caliber. The new Douglas Havoc light bomber, has an armament arrangement resembling that of the B-25, with four .50 caliber guns mounted in a new solid nose, one .50 mounted on each side of the ship firing forward in the same fashion as the two .50's on each side of the Mitchell, two more .50's in a top turret which can be traversed to add to the straight-ahead fire power, and a flexible tunnel gun beneath the fuselage.

The latest version of the North American P-51 Mustang, superseding even that shown recently on these pages (Apr., 1944, p. 232) has a teardrop, full-view canopy and a top speed of more than 425 m.p.h. It is claimed to be the fastest military plane in the world. The new model has two more .50 caliber machine guns added to its armament for a total of six, while Republic's latest P-47 Thunderbolt has water injection devices and a broad-bladed propellor which lift faster than ever before its eight .50 caliber guns to the high altitude at which the plane is designed to do its most effective fighting.

The British also have been developing their fighters, their latest announced improvement being a Mark 12 Spitfire designed for "outstanding performance at low altitudes." This is a radical departure for the Spitfire, which several years ago was the best and one of the relatively few high-altitude fighters. Its wings have been clipped and its power plant stepped up for improved maneuverability and greater speed and rate of climb at low altitudes. Some Washington aviation experts believe that the Royal Air Force's new superfighter, which has been scheduled to go into action this spring, is a jet-propelled craft.

German "Off Center" Plane

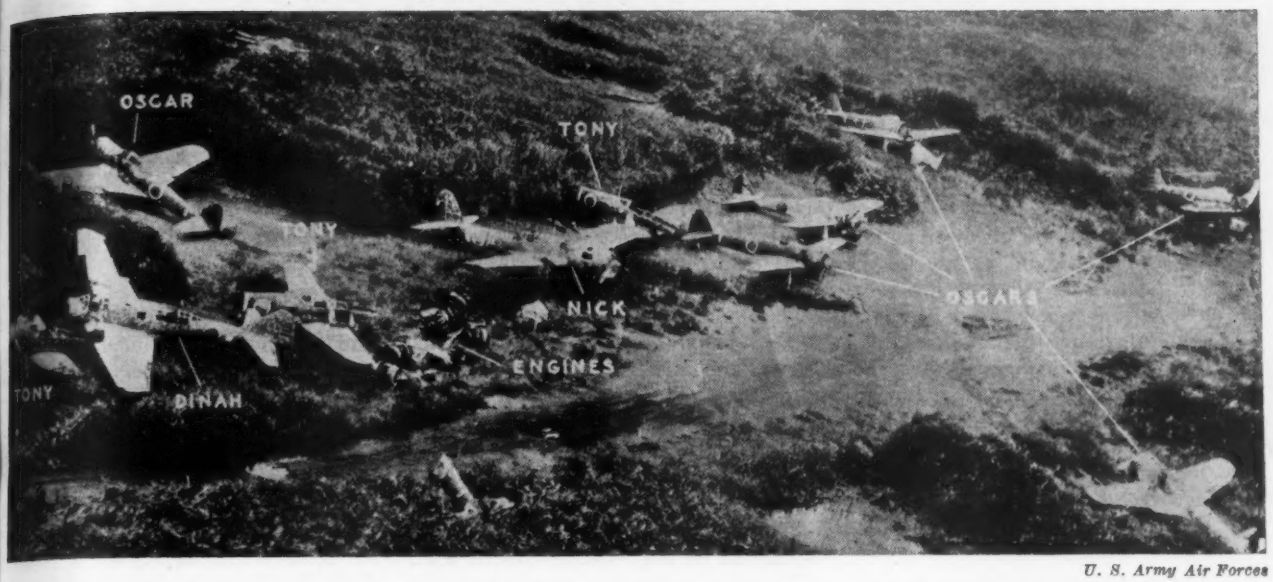
The Germans recently released to the Swedish press pictures of an airplane which resembles nothing that ever flew before. The plane, described as "asymetrical plane BV-141," in production, appears to have about the over-all dimensions of a B-26 Marauder, with broad, square-tipped wings. Its single engine, with an inordinately broad propellor, is mounted in orthodox fashion at the front of a round, slim fuselage which is off-center on the wing, balanced to the right by a long, slim nacelle inclosing the cockpit. Relatively indistinct photographs relayed to the United States appear to show a plastic-inclosed gunner's cockpit at the rear of the nacelle, which is perhaps one-third the length of the fuselage. The right stabilizer and elevator appear to project hardly beyond the right side of the fuselage, while the left stabilizer and elevator seem to be larger proportionately than normal. The entire stabilizer-elevator assembly appears to be mounted some distance above the top of the fuselage, although not so

Wood and Concrete Used in German Mine

Signal Corps.

One of the latest German anti-personnel weapons is this mine, consisting of a wooden mounting stake and a hollow concrete cylinder in which metal slugs are imbedded and which incloses a charge that shatters the concrete sleeve, hurling particles over a wide area. The mine can be used alone but is often used in pairs with a trip wire between the two. It has much the same effect as the "Bouncing Betty" (PRODUCT ENGINEERING, Mar. 1944, p. 164) but is easier to install, costs less to manufacture and is more difficult to locate with a mine detector. However, it is not ordinarily buried.

AAF Designates Japanese Aircraft by Nicknames



U. S. Army Air Forces

Four different types of Jap aircraft, nicknamed "Tony," "Oscar," "Nick" and "Dinah" by the Army Air Forces are shown in this picture made from a low-flying plane over a fighter dispersal area of the Vunakanau airfield at Rabaul, New Britain. These planes have been piled in a salvage area after being damaged by the repeated bombing and strafing attacks which have rendered Rabaul largely useless to the Japs. The names given these craft are not only nicknames awarded by our combat pilots but are also the official War Department designations for these planes, since the Japs have an aircraft production and issuance system which is unlike our own and which is not susceptible to our designation of successive models. Thus, "Oscar" is probably last winter's version of an earlier "Zero". "Tony," "Dinah" and "Nick" are too badly shot up to tell what they are.

high on the rudder as in the British Barracuda torpedo bomber where the stabilizer assembly is mounted well above the centerline of the fin and rudder.

As transmitted by radio from Sweden, the picture is just indistinct enough to indicate at first glimpse that the plane is in flight, but the fact that the propellor is motionless and a human figure can be seen half-erect in the off-center nacelle, as well as the appearance of what resembles two servicing ladders, indicates that it is pictured on the ground.

Another picture from Sweden shows German officers operating a sound-detecting device which amplifies noises from building wreckage in the search for bombing victims. The background of the picture shows wreckage enough to encourage even the most skeptical assayer of bomb damage.

Focke-Wulf "Lightning"

Other reports from the fighting fronts disclose that the Germans have used their latest fighter, the Focke-Wulf 189, a twin-fuselage plane resembling the Lockheed P-38 Lightning, to defend Berlin for the first time. Also, London observers noted that the latest German tanks have long, sloping frontal armor and new tracks, both of which look as though they resemble Russian designs.

Tests on a Focke-Wulf 190 single-engine German fighter made of parts of two captured planes showed U. S. pilots that the plane is highly maneuverable. The plane, which weighs about four tons, is powered with a 14-cylinder, twin-row radial engine of 1,600-hp. It's wing span is 34.5 ft. and its most effective altitude is between 12,000 and 15,000 feet. It is armed with two cannon built into the wing roots and twin light machine guns mounted in the fuselage, all of which are synchronized to fire through the propellor arc. The landing gear is operated electrically, with a hand release lever to lower the wheels if the electrical system is shot out. Manipulation of an emergency release for the canopy over the pilot fires a small cartridge which releases gas into a cylinder, actuating a piston which pulls the canopy off. Army and Bell Aircraft test pilots who flew the plane were amazed at the plane's responsiveness to the lightest manipulation of the controls.

B-29 Production Climbing

On the heavy bomber side, production of Boeing's B-29 "Super" Fortress is picking up, scheduled to equal that of the B-17 Fortress soon after the first of the year. Total heavy bomber production in U. S. plants each month is more than twice that of all medium bombers, despite the vast difference in man-hours per plane. In one recent month heavy bomber output was more than 60 percent ahead of the production of all single- and double-engine primary, basic and advanced trainers combined. Peak of heavy bomber production is still to be reached, while trainer output has been declining for months.

Loads of small and medium bombs carried by American planes of all types have been increased by 75 percent by an invention announced recently by the ordnance section of the Air Forces Command in England. Armorers now sling two or three bombs from a single rack by coupling them with a loop of tin cabling and a snap fastener hook, allowing a cluster of bombs to be carried where only one could be slung before. The device works with every type of bomb except the one- and two-ton blockbusters.

Elsewhere on the secret weapons front, the first public mention of the vast secret program in the Northwest was made in the House of Representatives where Congressmen were told of a "new weapon of warfare, developed by new manufacturing processes, that will turn large volumes of electricity

into the most important projectile yet developed." The plant manufacturing this weapon consumes a tremendous amount of electric power, but its secret has been so well guarded that even the Federal officials who supply the energy have no idea of the use to which it is put.

On the invasion coast in England, Brig. Gen. Henry Sayler, chief of Ordnance in the European theater, told U. S. troops they would go into Europe with weapons better than or the equal of anything the Axis had to offer.

Congress, meanwhile, followed up its approval of the largest Naval appropriations bill in history with approval of added millions for Naval ordnance, $35,000,000 of which will go into the improvement and manufacture of a new rocket weapon.

Patents for War

Inventors have received patents recently for war devices which range from a long, retractable cutting bar swung under aircraft to chemical anti-icing mixtures for aircraft wings.

Bell Aircraft was assigned a patent covering a method for making vulnerable and normally unarmored aircraft sections out of armor plate, while an English inventor was awarded a patent on a device to do away with electrically heated or inflated rubber boots for anti-icing protection. Under the new method, leading edges of wings are covered with a plastic solution of polymerized glycerol pthalate, over which is applied a solution of glycol stearate in ethylene glycol. The principle is that ice would not adhere to the slippery surface thus maintained, and would be carried away by the slip stream.

Another patent went to the inventor of an electrodynamic detector which sends and receives supersonic waves through water. Chief merit is that the signals would be undetectable except by a similarly sensitive device.

AAF at Sea

The Air Forces have released some details on its new "air-sea" rescue boat, a 52-ton, high-speed cruiser with a 13-man crew trained to rescue downed fliers and give them minor medical and surgical treatment. The boat, powered by two aircraft engines and two auxiliary engines, all of which use 100-octane aircraft fuel, has space for 20 injured men in addition to its crew. Cruising range is 2,500 mi. Plans call for enough of these craft to cover thoroughly the areas over which our planes customarily fly.

New Inspection Devices

A small sound-frequency tester and a 1,000,000-volt X-ray are the latest ammunition inspection devices to be pressed into service by Army Ordnance.

Ordnance tests 20-mm. shells with a 70-lb. portable device known as Sonotest, originally developed as an automatic method of detecting bad coins and making change for drink-vending machines. The shell is struck on an anvil and the sound wave recorded by the Sonotest, which distinguishes and measures the frequency, amplitude and duration of the sound wave. A green light flashes if the shell is O.K. after being bounced on its base and its side. No light is the signal for a rejected shell. Even the smallest cracks or defects can be shown up by the device. After one day of instruction and practice a girl can inspect several hundred shells hourly.

The 1,000,000-volt X-ray machine operates at the other end of the ammunition line, photographing several large shells at one time as they pass on a moving line and showing up the smallest cracks in shell casings or cavities in charges. It is estimated that 3,000 to 5,000 shells can be inspected daily by one machine.

The unit is also used to register size, intensity and location of powder flashes and progressive ignition of charges, and in shell tests records fragmentation to indicate the effectiveness of the projectile. Ordnance chemists photograph the various charges for color to determine the effectiveness of given charges and to determine the safety of these loads. Color may determine the state or the age of an explosive.

Gas Saver?

A device which injects water into airplane engine cylinders to furnish added speed for short periods has been tried in combat by the Army Air Forces and approved. Pratt and Whitney engineers studied the device as long ago as late 1942, producing some conversion units pending acceptance.

Pilots can get added bursts of speed merely by pressing a switch, and thus can get out of trouble or into attacking position more easily. The device obtains better cooling effect with water than with oil. The susceptibility to detonation, which limits the power that can be taken from a cylinder, is lessened by the presence of water and more power is produced because a leaner mixture can be used.

Heavy Italian Artillery Pressed Into Service

Signal Corps

An Italian crew is shown swabbing out this 194-mm. captured Italian railroad gun which the Allies have pressed into service on the Cassino front, where the need for long-range, heavy-caliber artillery proved so great that the U. S. heavy cannon construction program now progresses under top priorities. This gun is less mobile than our own 8-inch (200-mm., approximately) and 240-mm. cannon which are moved by motor. The area immediately behind the breech is considerably more cramped than that in which the crew of a U. S. 240-mm. gun works, which could reduce the relative efficiency.

The Plans of Yesterday

THE greatest invasion of Continental Europe in all history may have been launched by the time these words have been set in type. If not, it is certain that the powerful all-out offensive will be set in motion soon. Nobody can be certain of the outcome. But the United Nations are supremely confident that it will resolve itself into a notable victory leading to an early and complete surrender of Nazi Germany. There are many good reasons for this confidence.

Vast quantities of the finest military equipment yet conceived stand ready and waiting throughout England. Tens of thousands of planes are poised on hundreds of fully equipped airfields. Countless tanks, guns, construction equipment, Signal Corps apparatus and Quartermaster supplies stand ready for swift removal on railroad networks to embarkation points. Harbors, rivers and coves are filled with ships of all descriptions, many specially designed, in readiness for the invasion signal. Millions of thoroughly trained and toughened soldiers and sailors are chafing for action, eager for the command that will launch them as an irresistible conquering force.

If one could but see from on high the whole invasion in a grand panoramic view, the sight would be awesome and spell-binding in its effects, numbing all thoughts except the soul-stirring greatness of the action and the terrible sacrifice it entails. The mind could not be expected to dwell on the events and efforts that created the monstrous aggregation of war machines and placed them into effective use. The behind-the-scenes preparations stand out, however, in poignant relief.

Laboratories have been operating around the clock to hasten the pace of turning out superior war equipment. New materials, new processes, new production conceptions—all have emerged into a mighty armament program. Manpower, the ever-important force behind this armament, has been trained thoroughly in swamps, deserts and on the seas. Together they represent the blueprints of invasion preparedness.

The plans of yesterday become the realities of today. Our military machine is a thrilling reality today. In its fulfillment, we are aware that the most powerful striking force in all history is prepared to crush the planned tyranny of a fanatic and the distorted ego of a people that would be "the master race." Soon the enemy must bow to the unfaltering determination of the United Nations, and the torch of freedom will banish the shadow of slavery.

As our great air and sea armadas, laden with over-powering men and machines of war, move forward to battle with clocklike precision, we see the fulfillment of the plans of yesterday.

In all great undertakings, the accomplishments of today are but the plans of yesterday. And by the same token, the plans of today determine the accomplishments of tomorrow. May we plan for the world at peace with the same thoroughness, grandeur and self-sacrifice as we planned for the world at war.

G. F. Nordenholt.

Effects of Inertia Forces In Multicylinder Engines

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Northwestern Technological Institute

The previous article, "Analysis of Inertia Forces in Reciprocating Engines," May Product Engineering, dealt with the origin and nature of the inertia forces in a one-cylinder engine. The effects of such forces and those resulting from gas pressure in multicylinder engines are discussed here. Equations are given for determining the inertia effects mathematically.

IT IS usual practice to separate the resultant inertia force on an engine into two parts: (1) Primary inertia force, and (2) secondary inertia force.

At any running speed, the intensity of the primary force fluctuates cyclically at the speed of rotation of the engine, while the secondary fluctuates at twice engine speed. These forces are sometimes spoken of as the "first and second harmonic" forces.

The resultant inertia force on the engine, assuming that the rotating end of the rod is counterweighted, as given by Equation (25) [Equations (1) to (27) were derived and Figs. 1 to 11 were presented in the previous article.] can also be written as

$$R_1' = F_2 + F_p = \frac{W_2 + W_p}{g} A_b$$

$$= \frac{W_2 + W_p}{g} r\omega^2 \left(\cos\theta + \frac{r}{l} \cos 2\theta \right) \quad (28)$$

This resultant force when separated into two parts becomes

$$\text{Primary inertia force} = \frac{W_2 + W_p}{g} r\omega^2 \cos\theta \quad (29)$$

$$\text{Secondary inertia force} = \frac{W_2 + W_p}{g} \frac{r^2\omega^2}{l} \cos 2\theta \quad (30)$$

TRANSVERSE INERTIA MOMENT. All forces and reactions so far discussed, have been considered as lying in two dimensions. The engine is, of course, a three dimensional body. In general the inertia forces will not be located at the mid-point of the supports of the engine. This is especially true of multicylinder engines where inertia forces are acting in the various cylinders located throughout the length of the crankshaft. The inertia forces thus tend to rotate the entire engine about a cross-wise axis which is perpendicular to both the cylinder bore and the crankshaft.

In analyzing multicylinder engines of different numbers of cylinders and crank arrangements it is customary to consider the effects of the primary and secondary forces separately. Thus for a given engine it can be determined whether or not the primary forces and the moment resulting from them are in balance, and also whether or not the secondary forces and moments are in balance. In this connection the word "moment" refers to the moment about a transverse axis as explained in the preceding paragraph.

CONDITION OF BALANCE FOR MULTICYLINDER ENGINES. In the typical four-cylinder engine shown in Fig. 12 the long arrows F represent the primary forces and the short arrows F' the secondary. These are determined from Equations (29) and (30). In all cases θ equals 0 deg. at the head end dead center.

The condition of balance for this engine is noted on Fig. 12. The results are valid for any value of angle θ. The cylinders are assumed to be equally spaced along the crankshaft.

The condition of balance for another four-cylinder engine of different type crank arrangement is shown in Fig. 13. Also the condition of balance for a six-cylinder engine is shown in Fig. 14. Note that this engine is completely balanced.

A V-8 engine with 90 deg. between banks is shown in Fig. 15. For clarity in drafting one bank is shown vertical and the other horizontal.

The reactions and shaft and frame moments for these engines have not been shown on the drawings.

GAS FORCES IN ENGINE. Gas force on the piston F'_4 is found by multiplying the unit pressure by the area of the piston. When rod and piston together are considered as the free body the equilibrium of the forces is shown in Fig. 16. Note that for gas forces the connecting rod is a two-force member

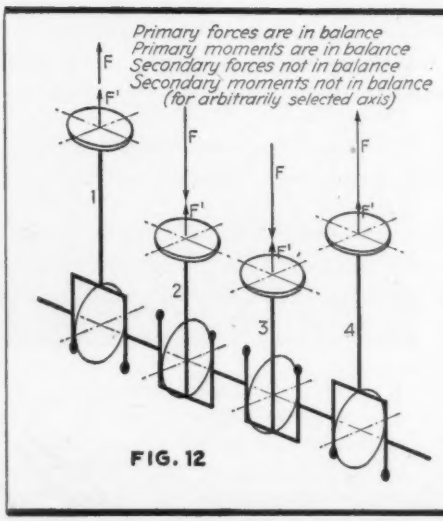


FIG. 12

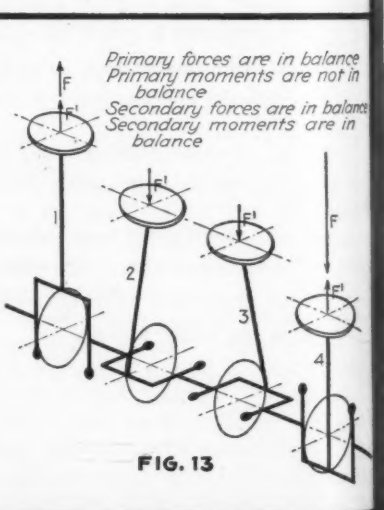


FIG. 13

Fig. 12—Inertia forces of four-cylinder engine. Cranks at 0, 180, 180 and 0 degrees.
Fig. 13—Inertia forces of four-cylinder engine. Cranks at 0, 90, 270, and 180 degrees.

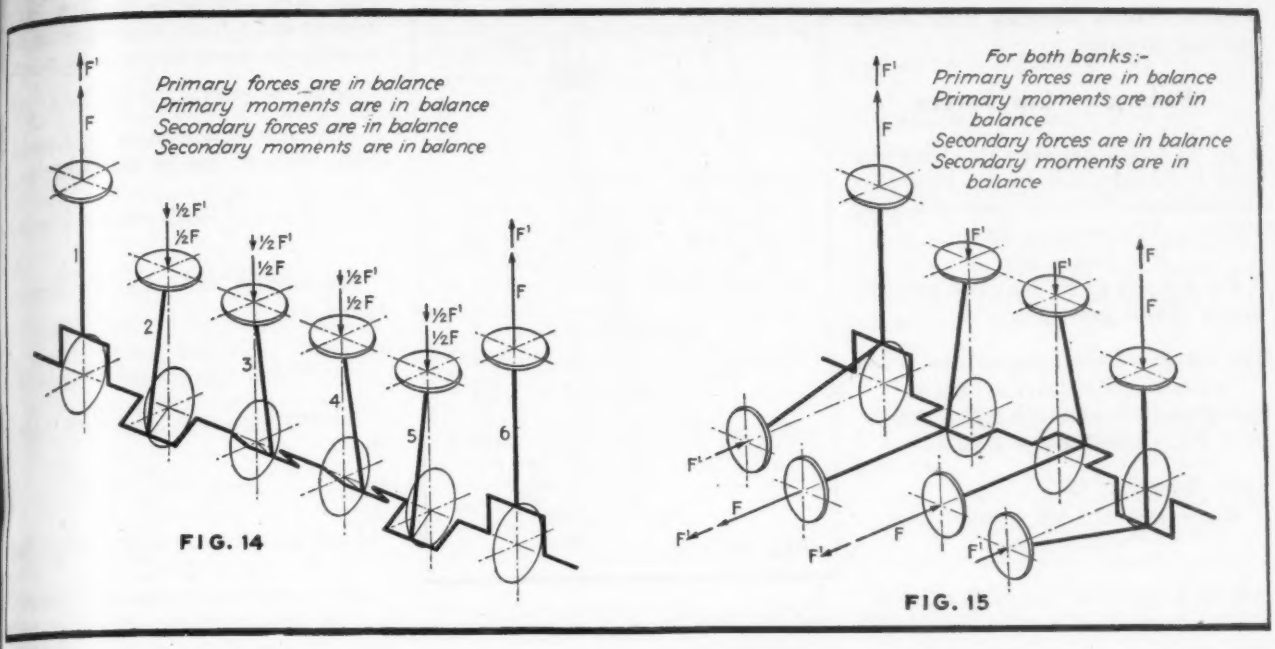

Primary forces are in balance
Primary moments are in balance
Secondary forces are in balance
Secondary moments are in balance
For both banks:-
Primary forces are in balance
Primary moments are not in balance
Secondary forces are in balance
Secondary moments are in balance

FIG. 14

FIG. 15

Fig. 14—Inertia forces of six-cylinder engine. Cranks at 0, 120, 240, 240, 120, and 0 degrees.
Fig. 15—Inertia forces of V-8 engine. For vertical bank cranks at 0, 90, 270, and 180 degrees.

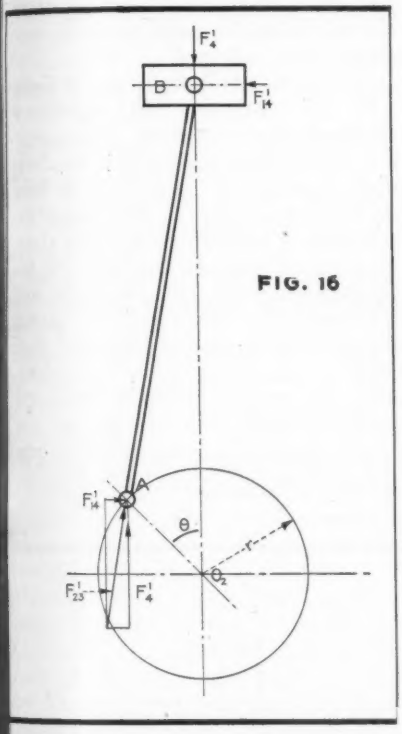


FIG. 16

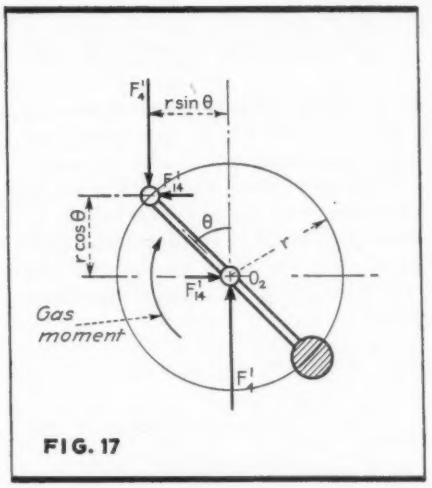


FIG. 17

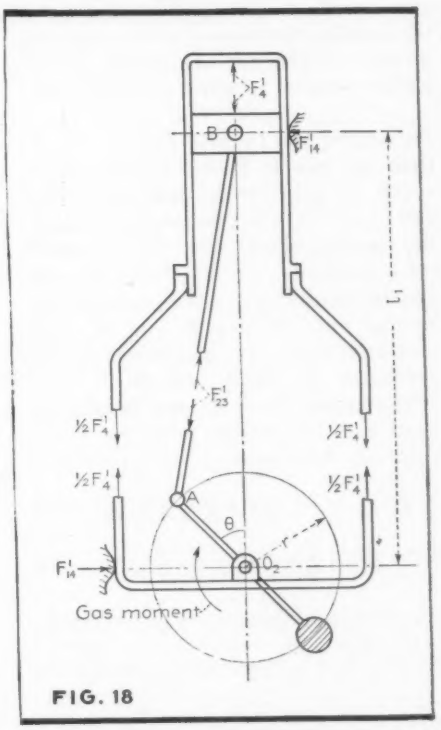


FIG. 18

Fig. 16—Equilibrium of gas forces on piston and rod.

Fig. 17—Equilibrium of crankshaft.

Fig. 18—Equilibrium of gas forces for entire engine.

and that resultant F'_{23} lies in the direction of the rod.

The condition for the crankshaft is shown in Fig. 17. The gas torque is given by

$$M_{gas} = F'_4 r \sin\theta + F'_{14} r \cos\theta \qquad (31)$$

The whole engine and the forces acting thereon are shown in Fig. 18. The gas forces are characterized by the fact that no vertical reaction force is required for equilibrium of the engine. To further illustrate this fact the crank case and connecting rod have been broken apart in Fig. 18 to indicate that each portion is in complete equilibrium vertically within itself without the need of an externally applied force.

From Fig. 18 the expression for the frame moment can be written as

$$M'_{frame} = F'_{14} l_1 \qquad (32)$$

So far as gas forces are concerned the gas torque of Equation (31) and the frame moment of Equation (32) are numerically equal. The foundation reactions F'_{14} of Fig. 18 are not present in an engine with a conventional type base as shown in Fig. 11. The frame moment $F'_{14}\ l_1$ is carried by forces $F'_{14} l_1/2m$ at the foundation lugs.

The computations of the gas forces are kept separate from those resulting from inertia. There is of course no numerical connection between them. The resultant forces at any point are

found by adding algebraically the separate effects resulting from inertia and gas pressure.

Example—Gas Forces

In the numerical example which was used in "Analysis of Inertia Forces In Reciprocating Engines," page 344, May, PRODUCT ENGINEERING, let

Bore = 3 in.

For θ equal to 45 deg., gas pressure equals 155 lb. per sq. in.

The results of the computations are

$$F'_4 = \pi \times 3^2 \times 155/4 = 1{,}098 \text{ lb.}$$
$$F'_{14} = \tfrac{1}{4}F'_4 \tan \varphi = 1{,}098 \times 0.1835 = 202 \text{ lb.}$$
$$F'_{23} = 1{,}098/\cos \varphi = 1{,}116 \text{ lb.}$$

From Equation (31)

$$M_{xx} = 1{,}098 \times 1.856 + 202 \times 1.856 = 2{,}410 \text{ in lb.}$$

INERTIA EFFECTS BY USE OF EQUATIONS. The semi-graphical method which has been described for determining the inertia forces gives accurate results. The method is somewhat lengthy if results are desired for many values of the crank angle θ. The process does serve the valuable function of giving a mental picture of the various inertia forces and the manner in which they originate.

EQUATIONS FOR INERTIA FORCES. Equations will now be given (derivations for which are given in the appendix at the end of this article), by means of which the various effects may be computed mathematically. Fig. 19 shows the kinetically equivalent system for the connecting rod. Weights W_a and W_b and lengths e_1 and e_2 are determined by the previously described methods.

The origin of coordinates is taken at head end dead center with the x-axis vertically downward.

$$F_a^v = \frac{W_a}{g} r\omega^2 (\cos\theta + \frac{e_1 r}{l^2} \cos 2\theta) \quad (33)$$

$$F_a^h = F_1^h = \frac{W_1}{g} r\omega^2 \sin\theta = \frac{W_2 b}{ga} r\omega^2 \sin\theta \quad (34)$$

As previously given by Equation (15)

$$F_b = \frac{W_b}{g} A_b = \frac{W_b}{g} r\omega^2 (\cos\theta + \frac{r}{l} \cos 2\theta) \quad (35)$$

$$F^r_{14} = \frac{W_2}{2g} r^2\omega^2 \left[\frac{2\, e_1 b}{ra\, l} \sin\theta + \frac{1}{l} \sin 2\theta + \frac{r}{l^2}\left(1 - \frac{e_1 b}{al}\right)(\sin 3\theta - \sin\theta) \right] \quad (36)$$

Force F^r_{14} in Equation (36) is caused by the effect of the rod alone. Note that in Fig. 7, force F_{14} included the effects of both rod and piston.

An equation for F^h_{23} can be derived from Equations (34) and (36):

$$F^h_{23} = F^h_a - F_{14} = \frac{W_2}{2g} r^2\omega^2 \left[\frac{2e_2 b}{ral} \sin\theta - \frac{1}{l} \sin 2\theta + \frac{r}{l^2}(1 - \frac{e_1 b}{al})(\sin 3\theta - \sin\theta) \right] \quad (37)$$

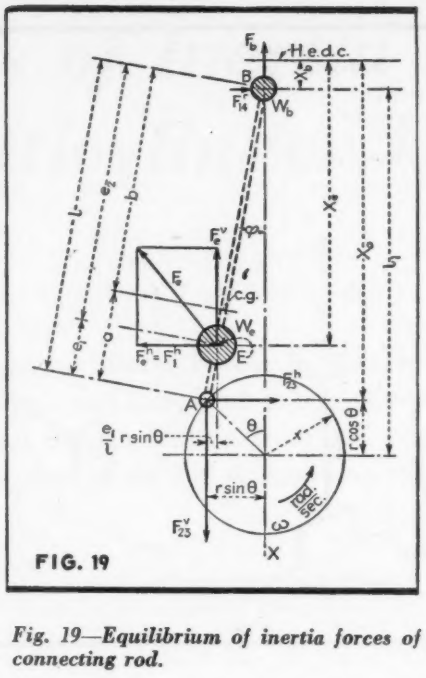


FIG. 19

Fig. 19—Equilibrium of inertia forces of connecting rod.

From Equations (33) and (35), F^v_{23} is

$$F^v_{23} = F^v_a + F_b = \frac{W_2}{2g} r^2\omega^2 \left(\frac{2l}{ar} \cos\theta + \frac{2}{l} \cos 2\theta \right) \quad (38)$$

SHAFT MOMENT CAUSED BY ROD ALONE. Forces F^v_{23} and F^h_{23} of the crankshaft on the connecting rod become the equal and opposite forces F^v_{32} and F^h_{32} of the connecting rod on the crankshaft as shown in Fig. 20. As previously mentioned only the mass of the rod has been considered in computing these forces.

$$M^r_{shaft} = \frac{W_2}{2g} r^2\omega^2 \left[-\frac{r}{2l} \sin\theta + \left(1 + \frac{e_1 b}{al}\right) \sin 2\theta + \frac{3r}{2l} \sin 3\theta \right] \quad (39)$$

In Equation (39) factors of r/l having exponents to the square and greater have been disregarded.

FRAME MOMENT CAUSED BY ROD ALONE. The frame moment M^r_{frame} caused by the rod alone is found from

$$l_1 = r\cos\theta + l - \frac{r^2}{4l} + \frac{r^2}{4l} \cos 2\theta \quad (40)$$

$$M^r_{frame} = -\frac{W_2}{2g} r^2\omega^2 \left[\left\{ \frac{e_1 b}{al} \left(\frac{r}{4l} + \frac{2l}{r} \right) - \frac{r}{2l} \right\} \sin\theta + \left(\frac{e_1 b}{al} + 1 \right) \sin 2\theta + \frac{3r}{4l} \left(2 - \frac{e_1 b}{al} \right) \sin 3\theta \right] \quad (41)$$

As before terms in higher powers of r/l have been omitted.

SHAFT MOMENT AND FRAME MOMENT CAUSED BY THE PISTON ALONE. The inertia force of the piston causes a normal reaction of the cylinder wall on the piston equal to

$$F^p_{14} = F_p \tan\phi \quad (42)$$

This force produces both a shaft moment and a frame moment which are numerically equal but opposite in sign.

$$M^p_{shaft} = -M^p_{frame} = l_1 F_p \tan\phi \quad (43)$$

The value of l_1 is given by Equation (40), while F_p can be found by

$$F_p = \frac{W_p}{g} A_b = \frac{W_p}{g} r\omega^2 \left(\cos\theta + \frac{r}{l} \cos 2\theta \right) \quad (44)$$

The tangent of ϕ may be approximated as

$$\tan\phi = \frac{r \sin\theta}{l \cos\phi} \simeq \frac{r}{l} \sin\theta \quad (45)$$

Substituting into Equation (43) yields.

$$M^p_{shaft} = -M^p_{frame} = \frac{W_p}{2g} r^2\omega^2 \times \left[-\frac{r}{2l} \sin\theta + \sin 2\theta + \frac{3r}{2l} \sin 3\theta \right] \quad (46)$$

The foregoing equations for computing the inertia effects are exact with the exception of the omission of terms in higher powers of r/l. These equations are less accurate for values of θ in the neighborhood of 90 deg., but for this portion of the cycle the inertia effects are less than for crank positions near either dead center.

A positive result from any of Equations (39), (41), or (46) indicates a counterclockwise moment, and a negative result indicates moment in the clockwise direction. It is difficult to keep track of the signs or the directions of the moments by mathematical means alone. If one is thoroughly familiar with the graphical method, as presented and described in "Analysis of Inertia Forces in Reciprocating Engines," May, PRODUCT ENGINEERING, he can determine the numerical values from the equations and then decide on the proper direction of the moments from consideration of the physical situation.

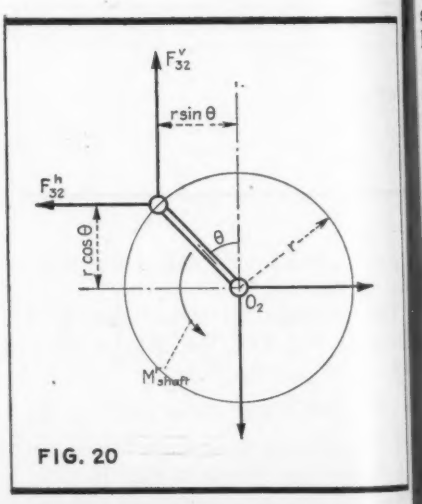


FIG. 20

Fig. 20—Equilibrium of inertia forces on crankshaft.

The resultant values of the shaft moment and frame moment are secured by adding the separate effects as produced by connecting rod and piston. Proper regard must be paid to the direction or sign of each separate part.

REFERENCE: Den Hartog, "Mechanical Vibrations," McGraw-Hill Book Company, 2nd Edition 1940, page 203.

Numerical Example

Using the data of the engine used in the example page 344, May, PRODUCT ENGINEERING, substitution will be made in the foregoing equations as a check on the graphical work.

$$\frac{e_1 b}{a l} = \frac{1.824 \times 7.337}{2.944 \times 10.281} = 0.442$$

Substitution in Equation (39) for the shaft moment caused by rod alone gives

$$M^r_{shaft} = 400 \text{ in. lb.}$$

Using Equation (46) for shaft moment caused by piston gives

$$M^p_{shaft} = M^p_{frame} = 690 \text{ in. lb.}$$

The total shaft moment

$$M_{shaft} = \sum M^r_{shaft} + M^p_{shaft} = 400 + 690 = 1{,}090 \text{ in. lb.}$$

This compares with 1,100 in. lb. as found by the graphical method. From Equation (41) the frame moment caused by the rod can be found from

$$M^r_{frame} = 1{,}000 \text{ in lb.}$$

The total frame moment then becomes

$$M_{frame} = M^r_{frame} + M^p_{frame} = 1{,}000 + 690 = 1{,}690 \text{ in. lb.}$$

The graphical method gave a value for this of 1,700 in. lb.

The frame moment may be checked by first finding the forces and then multiplying by arm l_1.

From Equation (36), $F^r_{14} = 83$ lb.

$$\text{Force } F^p_{14} = F_p \tan \phi = 318 \times 0.1835 = 58 \text{ lb}$$

$$M_{frame} = 12.0\,(83 + 58) = 1{,}690 \text{ in. lb.}$$

In Fig. 7 if a horizontal is drawn through the end of F_b vector to intersection with F^t_{23}, force F^r_{14} is found to be equal to 83 pounds.

APPENDIX. The detailed mathematical steps necessary to the derivation of Equations (33) to (46) will be briefly sketched for the benefit of those who are interested in the manner in which the various expressions originate.

From Fig. 19

$$x_e = x_b + (x_a - x_b)\frac{e_2}{l} = \frac{e_1}{l} x_b + \frac{e_2}{l} x_a$$

$$A^r_e = \frac{d^2 x_e}{dt^2} = \frac{e_1}{l}\frac{d^2 X_b}{dt^2} + \frac{e_2}{l}\frac{d^2 x_a}{dt^2} = \frac{e_1}{l} r\,\omega^2\left(\cos\theta + \frac{r}{l}\cos 2\theta\right) + \frac{e_2}{l} r\,\omega^2 \cos\theta = r\,\omega^2\left(\cos\theta + \frac{e_1 r}{l^2}\cos 2\theta\right)$$

The foregoing expression becomes Equation (33) upon multiplication by the mass W_e/g.

By taking moments in Fig. 1(*A*)

$$W_1 = \frac{b}{a} W_2 \qquad (a)$$

This equation, in view of the fact that F^h_e equals F^h_1 in Fig. 9 and also Fig. 19, and also F_1 equals $W_1 r\,\omega^2/g$, leads directly to Equation (34).

To derive Equation (36), take moments about point *A*

$$F_{14}{}^r\, l \cos\varphi = F^h_e\, e_1 \cos\varphi + F^v_e \frac{e_1}{l} r \sin\theta + F_b\, r \sin\theta \qquad (b)$$

As shown by Equation (7) the cosine of ϕ can be written as

$$\cos\varphi = 1 - \frac{r^2}{2l^2}\sin^2\varphi + \ldots\ldots$$

In nearly all practical cases it is permissible to neglect values of the ratio r/l with an exponent of two or greater. This in effect is saying that the cosine of ϕ can be approximated as 1. Equation (*b*), after transposing factor l, becomes

$$F_{14}{}^r = \frac{e_1}{l} F^h_e + \frac{e_1 r}{l^2} F^v_e \sin\theta + \frac{r}{l} F_b \sin\theta \qquad (c)$$

The expressions for F^v_e, F^h_e and F_b from Equations (33), (34) and (35) respectively are substituted in Equation (*c*) giving

$$F_{14}{}^r = r\,\omega^2\left[\frac{e_1}{l}\frac{W_1}{g} + \frac{e_1}{l}\frac{r}{l}\frac{W_e}{g}\left(\cos\theta + \frac{e_1 r}{l^2}\cos 2\theta\right) + \frac{r}{l}\frac{W_b}{g}\left(\cos\theta + \frac{r}{l}\cos 2\theta\right)\right]\sin\theta \qquad (d)$$

From Figs. 1(*A*) and 2(*A*) taking moments about *B*

$$W_1 l = W b = W_e e_2$$
$$W_1 l = W_e (l - e_1)$$
$$\frac{W_e e_1}{l} = W_e - W \qquad (e)$$

Substituting Equations (*a*) and (*e*) into Equation (*d*) gives

$$F_{14}{}^r = \frac{W_2}{g} r^2 \omega^2\left[\frac{e_1 b}{r a l}\sin\theta + \frac{1}{l}\sin\theta\cos\theta + \frac{r}{l^2}\left(1 - \frac{e_1 b}{a l}\right)\sin\theta\cos 2\theta\right] \qquad (f)$$

By trigonometry it can be shown that

$$\sin\theta\cos\theta = \frac{1}{2}\sin 2\theta \qquad (g)$$

$$\sin\theta\cos 2\theta = \frac{1}{2}\left(\sin 3\theta - \sin\theta\right) \qquad (h)$$

$$\sin 2\theta\cos\theta = \frac{1}{2}\left(\sin 3\theta + \sin\theta\right) \qquad (i)$$

Substitution of Equations (*g*) and (*h*) into Equation (*f*) gives Equation (36).

In arriving at the final form for Equation (38) substitution was made of Equation (*e*), as well as the following relationship derived from Fig. 1(*A*)

$$W = \frac{W_2 l}{a} \qquad (j)$$

In obtaining Equation (39) substitution was made of Equations (37) and (38) into

$$M^r_{shaft} = F^v_{32}\, r \sin\theta - F^h_{32}\, r \cos\theta \qquad (k)$$

Factors of r/l having exponents to the square and greater have again been neglected. Use of Equations (*g*), (*h*) and (*i*) has also been made. The two following identities have also been used which utilize Equations (4) and (2).

$$e_1 b = (l - e_2)\, b = l\, b - e_2\, b = (a + b)\, b - r_b{}^2 = a\, b - r_c{}^2 \qquad (l)$$

$$\frac{l^2 - e_2 b}{a l} = \frac{(a+b)^2 - r_b{}^2}{a l} = \frac{a\,(a+b) + a\,b - r_c{}^2}{a l} = 1 + \frac{a\,b - r_c{}^2}{a l} = 1 + \frac{e_1 b}{a l} \qquad (m)$$

The frame moment M^r_{frame} caused by the rod alone is found from

$$M^r_{frame} = -F^r{}_{14}\, l_1 \qquad (n)$$

where $F_{14}{}^r$ does not include the effect of the piston.

Steps leading to Equation (40) are

$$l_1 = r\cos\theta + l\cos\varphi = r\cos\theta + l\,(1 - \sin^2\varphi)^{1/2} = r\cos\theta + l\,(1 - \frac{r^2}{l^2}\sin^2\theta)^{1/2} = r\cos\theta + l\,(1 - \frac{r^2}{2l^2}\sin^2\theta) = r\cos\theta + l\left(1 - \frac{r^2}{2l^2}\times\frac{1 - \cos 2\theta}{2}\right) = r\cos\theta + l\left(1 - \frac{r^2}{4l^2} + \frac{r^2\cos 2\theta}{4l^2}\right)$$

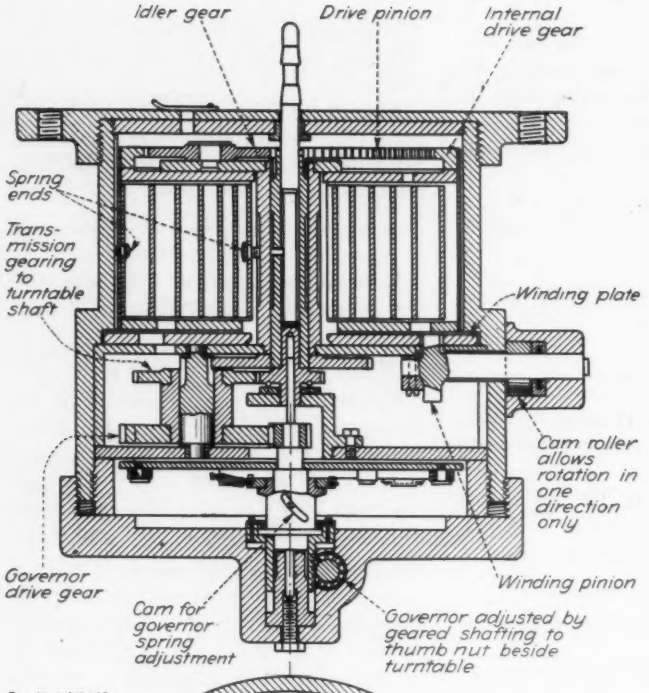
Equation (41) is obtained by substitution of Equations (36) and (40) into Equation (*n*). Use has again been made of Equations (*g*), (*h*) and (*i*).

Stratosphere Conditions Simulated in Test Chamber

FLIGHT TESTING of aircraft motors, generators, and controls at high altitudes can be eliminated with a low-temperature chamber developed by Westinghouse Electric & Manufacturing Company engineers. Atmospheric and humidity conditions at 70,000 ft., where temperature is —67 deg. F. and pressure is ¾ lb. per sq. in., can be duplicated. Only fresh air is circulated in the chamber. A mixture of crushed Dry Ice and varsol is used for the refrigerant. Because incoming air can also be heated and saturated with water, a complete flight cycle, from the take-off on a hot jungle landing strip and climbing at a normal rate to the cold, dry stratosphere, can be duplicated.

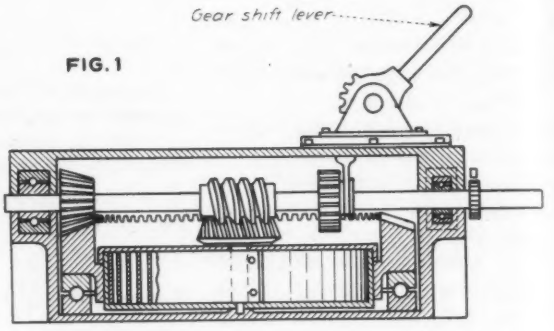
SPRING MOTORS AND TYPICAL

MANY applications of spring motors in clocks, phonographs, motion picture cameras, rotating barber poles, game machines and other mechanisms offer practical ideas for adaptation to any mechanism in which operation for an appreciable length of time is desirable. While spring motors are usually limited to comparatively small power applications where other sources of power are unavailable or impracticable, they may also be useful for intermittent operation requiring


Idler gear
Drive pinion
Internal drive gear
Spring ends
Trans-mission gearing to turntable shaft
Winding plate
Cam roller allows rotation in one direction only
Governor drive gear
Winding pinion
Cam for governor spring adjustment
Governor adjusted by geared shafting to thumb nut beside turntable

Pat No 1,616,142

FIG. 1



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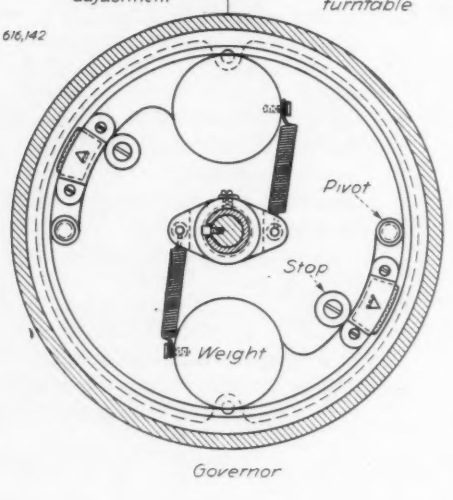
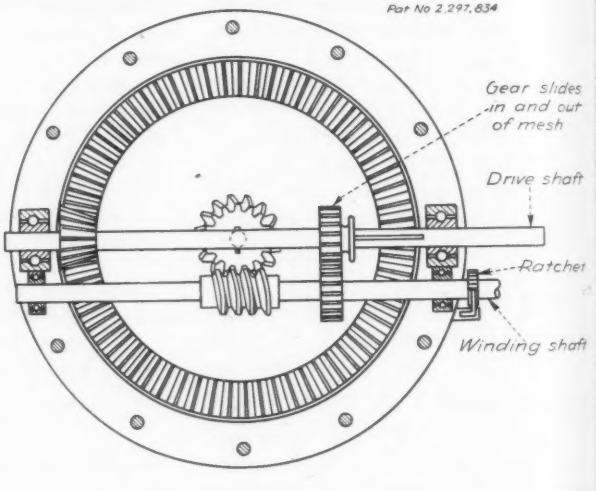


Governor

FIG. 2



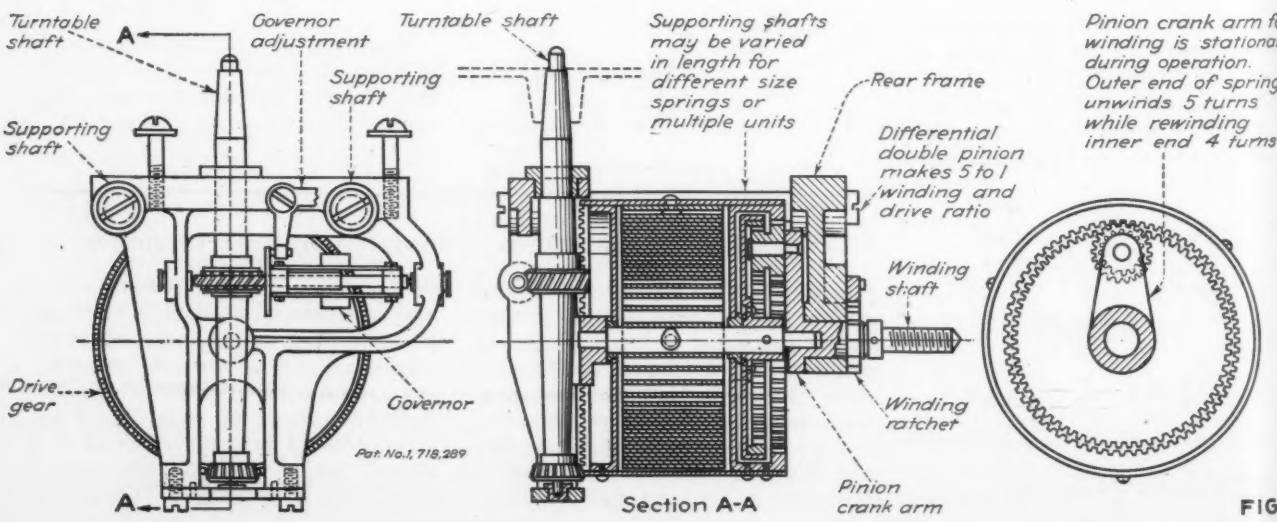
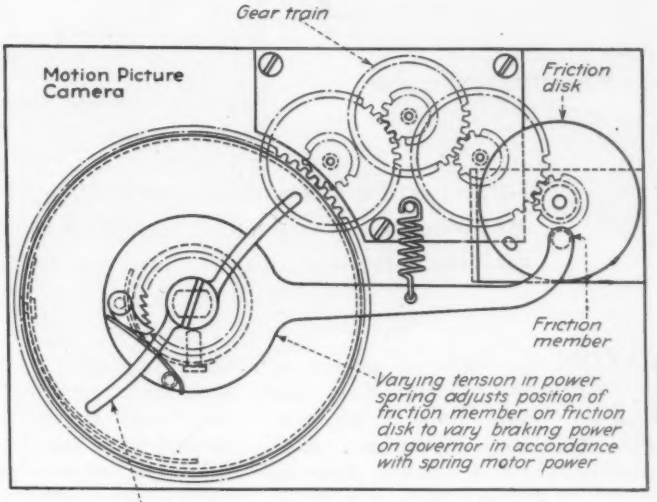

Turntable shaft
A
Governor adjustment
Supporting shaft
Supporting shaft
Drive gear
Governor
Pat No.1, 718,289
A
Turntable shaft
Supporting shafts may be varied in length for different size springs or multiple units
Rear frame
Differential double pinion makes 5 to 1 winding and drive ratio
Winding shaft
Winding ratchet
Pinion crank arm
Section A-A
Pinion crank arm for winding is stationary during operation. Outer end of spring unwinds 5 turns while rewinding inner end 4 turns

FIG. 3

ASSOCIATED MECHANISMS

comparatively high torque or high speed, using a low power electric motor or other means for building up energy.

The accompanying patented spring motor designs show various methods of transmission and control of spring motor power. Flat-coil springs, confined in drums, are most widely used because they are compact, produce torque directly, and permit long angular displacement. Gear trains and feed-back mechanisms hold down excess power so that it can be applied for a longer time, and governors are commonly used to regulate speed.


Gear train
Motion Picture Camera
Friction disk
Friction member
Varying tension in power spring adjusts position of friction member on friction disk to vary braking power on governor in accordance with spring motor power

Pat No. 2,095,670

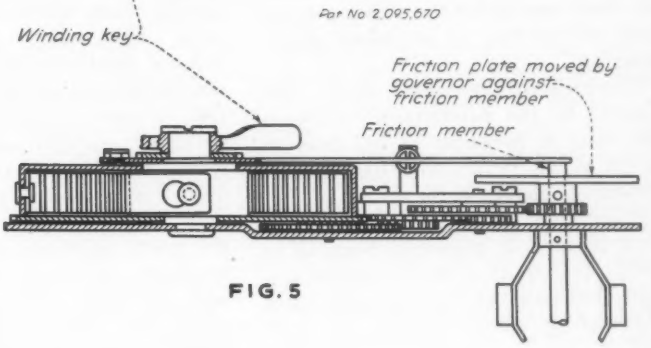


FIG. 5

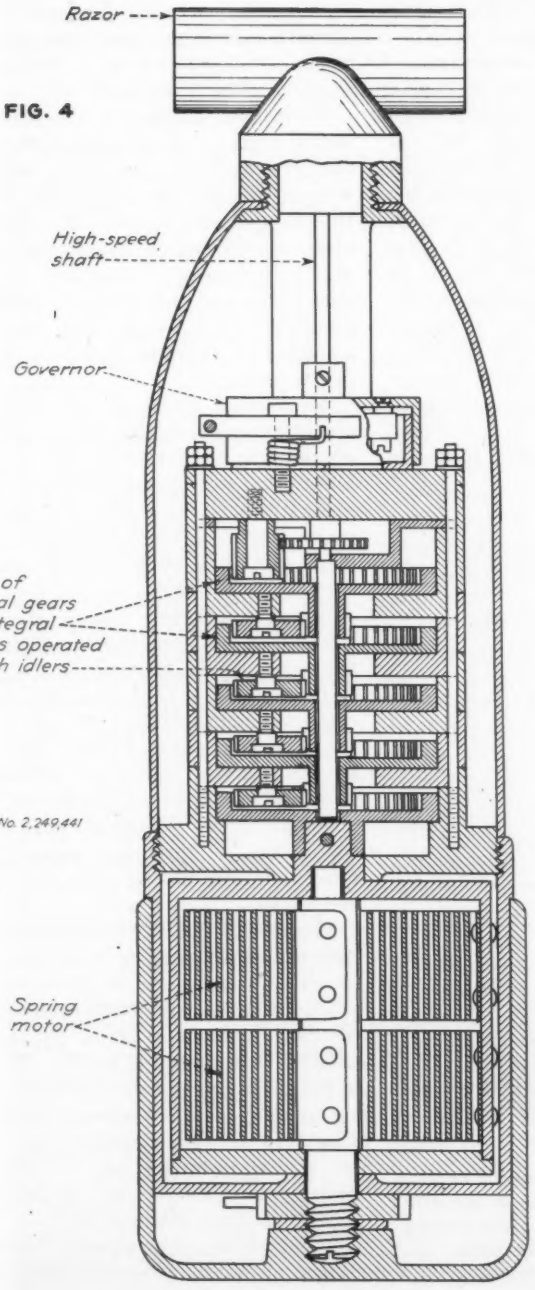


FIG. 4

Pat No. 2,249,441

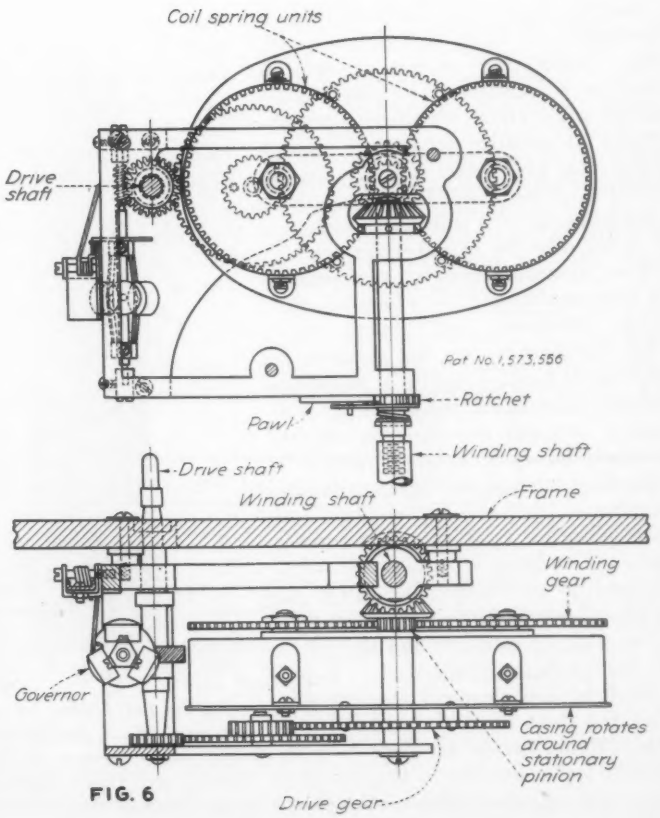


FIG. 6

Low-Pressure Laminating Adaptable to Large Parts

T. N. WILLCOX
Plastics Department, General Electric Company

Large parts and assemblies made of layers of fabric or paper impregnated with synthetic resins are now feasible because of developments in low-pressure molding. Design considerations for such moldings are covered in this article.

LAYERS of cloth or paper impregnated with synthetic resin are coming into wide use, especially for large lightweight, high-strength parts or assemblies. Development of low-pressure molding is one of the chief reasons for the growing popularity of this type of laminated plastic material.

Low-pressure molding, made economical by the development of resins that react at pressures of less than 15 lb. per sq. in., ranges from bare contact pressure to about 800 lb. per sq. in. For low cost and varied applications most work is done at pressures from 10 to 100 lb. per sq. in. Cotton, asbestos and glass cloths are the types of fabric used, and kraft or rag-base papers are common.

Bonding agents are thermosetting or thermoplastic. Urea- and phenolic-base resins typify those giving off volatile products of reaction. The unsaturated alkyds and styrene copolymers are examples of so-called solventless varnish resins that polymerize without volatile products of reaction. Polystyrene is a good example of a straight thermoplastic resin used for low-pressure work.

Low-pressure laminates are ordinarily non-metallic and, therefore, are electrical insulators and non-magnetic. These properties can be changed by addition of metal, graphite or other conductors. Insulation resistance and dielectric strength are critically affected by absorbed moisture and presence of impurities, such as conducting particles in asbestos laminates. Most cloth laminates absorb a relatively high percentage of moisture because of their sponge-like structure. The lower the molding pressures, the more voids there are to pick up moisture and the poorer are the insulating properties.

Thermal and chemical properties remain the same for high- and low-pressure molding except as effected by the slightly lower density of the low-pressure laminating. Other significant characteristics of low-pressure laminates are excellent vibrational damping, high fatigue strength and high residual strength after initial failure.

One of the principle advantages of low-pressure laminating is that inexpensive wood molds or forms can be used. This makes possible the economical production of small quantities without the expense of complicated dies that is characteristic of high-pressure molding. Another advantage is that large, complicated assemblies can be formed in one piece at reasonable cost.

In forming low-pressure laminates the press itself can be eliminated, if necessary, by using a vacuum blanket and the mold. This represents minimum tool investment. The vacuum firmly presses the laminated pieces to the contour of the supporting form. Heat is supplied by circulating hot air, infra-red lamps or steam channels cored in the form. If the size of the part permits, autoclaves or fluid baths make excellent sources of heat.

Hollow fan blades for industrial cooling towers reduce starting torque in the driving motor because of their light weight. They are rigid, vibration-resistant and not attacked by corrosive vapors.

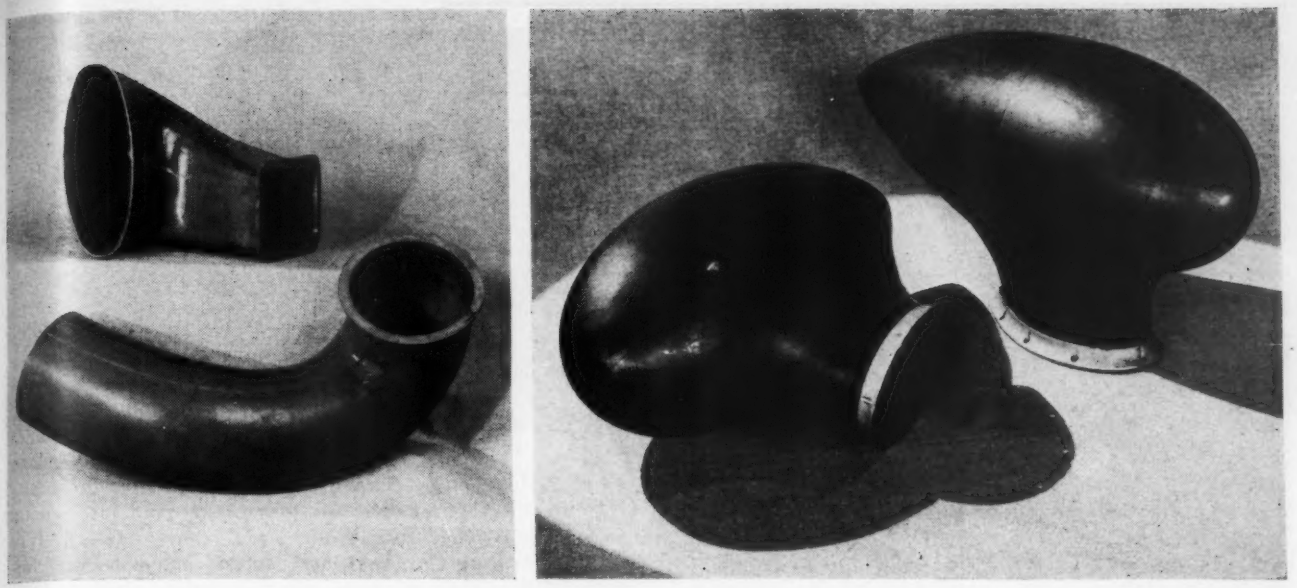
From the designer's viewpoint the flexible bag or diaphragm method has the drawback of producing only one side of the part to exact contour. Although the side against the bag is a close approximation, overlapped layers and wrinkles will show up. Further drawbacks are the limited number of bonding resins usable and the lower mechanical strengths obtained at very low pressure.

Mechanical strengths can be appreciably increased by the higher pressures obtained in an autoclave, hat press or other type of press. Well-equipped manufacturers are now in a position to make single parts at pressures up to 80 lb. per sq.in., such as small airplane fuselages and wings.

Because progress in low-pressure laminating has been rapid and changes are constantly being made as technique is improved, no hard and fast design rules can be given. In general, successful designing envisions the completed part or assembly and then breaking it down into a minimum of moldable components. Thus, a barrel becomes a simple two- or three-part assembly instead of several hoops, many staves and two heads.

Minimum, but safe, thickness of laminate in all parts is good economy. Of equal importance is the saving in curing time on thin cross-sections. In general, thicknesses below ½ in. are handled as a matter of routine. Thicker sections require special attention during manufacture. Uniform cross-sections help prevent warpage from residual cooling strains and, for thermosetting resins, reduce the possibility of overcuring thin sections.

With existing low-pressure thermosetting resins there is a limiting rate



Air ducts, left, have complex curved molded shapes. They are light, rigid and have molded external mounting flanges. The internal baffle is assembled by riveting. Loop antenna housings, right, are molded in a single piece of high-strength fabric laminate, which eliminates metallic fastenings in the radio-frequency field. Aluminum flanges are molded on.

at which heat can be added in a thick laminate. If temperature rises too fast, exothermic curing will carry the temperature high enough to char and blister the part. In thin molded sections this heat is readily transferred out of the part, allowing high temperatures and fast cures. Thick sections bonded with thermoplastic resins take disproportionately longer to mold because heat must be transferred both into and out of the part before it can be taken from the mold.

The ratio of strength to weight is a prime consideration in many applications. While it is inherently high, this ratio can be improved by a sandwich-type construction using balsa or some similar low-density material between outer layers of laminate.

Dimensional tolerances for low-pressure molding are not well established because not enough parts or assemblies have been made by competing manufacturers. A workable molding tolerance on thickness is about ± 10 percent. This takes into account overlapping layers on curved shapes where a rubber bag cannot iron out the irregularity. Proper choice of lamination thicknesses and number of layers makes possible closer approach to the required thickness on plane and simple-curved surfaces. Tolerances on lengths and widths can normally be met by molding oversize and trimming edges and ends to size.

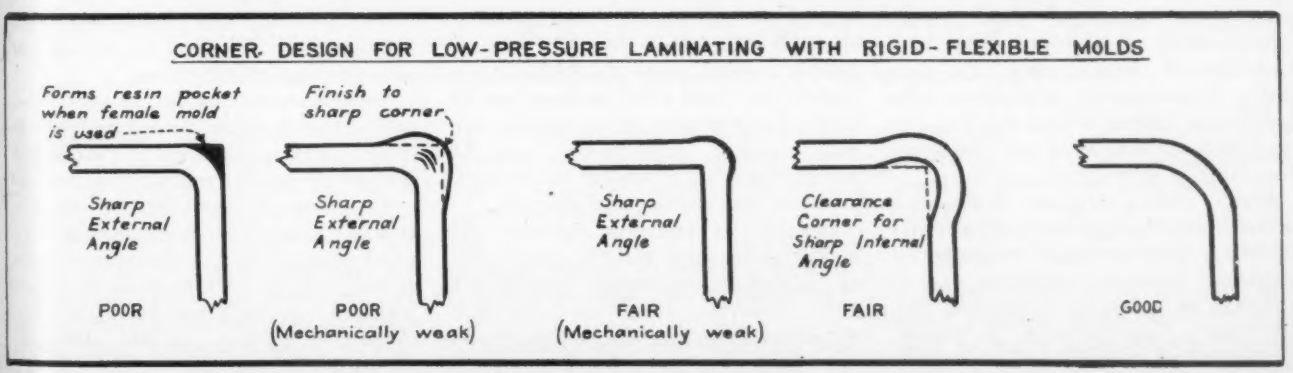
Shapes available in low-pressure laminating are extremely varied, running from large flat panels to the tortuous compound curves used in duct work. Flat panels are provided in many dimensions with both surfaces molded smooth. Large, thin flat sections tend to warp and require reinforcement. Simple curves in two dimensions can be obtained by flexing flat panels, hot or cold, or by pressing and curing in the curved form.

Cylinders are a special case of simple curvature. When made by winding and curing on a mandrel a smooth inside bore remains after the mandrel is extracted. Outside diameter can be centerless ground to required smoothness or dimensional tolerance.

Compound curves offer the widest field for low-pressure laminating. Simplest shapes to produce are surfaces of revolution, such as a hemispherical dome. If, however, the part has appreciable undercuts, such as in a one-piece loop-antenna housing, the mold becomes more complicated and expensive. The streamlined loop antenna housing illustrated above is a good example of how the engineering advantages of single-piece construction can outweigh relatively high tool costs.

Accuracy of curvature and profiles of compound-curved shapes depends on mold accuracy, allowances for compound shrinkage, correct molding cycle, uniformity of materials and proper support of the part in the completed assembly. Limited data on the circumference of a hemispherical housing show duplication of parts within a fraction of 1 percent on the side adjacent to the rigid mold.

Many parts have corners where material must turn suddenly into a new plane. A minimum radius equal to the thickness of cross-section should be



Comparative Properties of High- and Low-Pressure Phenolic-Bonded Fabric

	Low-Pressure (75 lb. per sq. in.) laminate, phenolic resin, 8 oz. cotton duck	High-Pressure (Grade C) laminate, phenolic resin, 8 oz. cotton duck	High-Pressure molded, chopped cloth, phenolic resin, 8 oz. cotton duck
Impact Strength, Izod, ft. lb. per in. of notch	4.9	5.0	3.0
Flexural Strength, lb. per sq. in.	18,600	20,000	10,000
Compressive Strength, lb. per sq. in.	27,400	40,000	25,000
Tensile Strength, lb. per sq. in.	9,000	10,000	6,300
Modulus of Elasticity in Tension, lb. per sq. in.	4×10^5	7×10^5	10×10^5
Water Absorption, percent, 24 hr.	3.3	1.5	1.0
Specific gravity	1.30	1.34	1.40

used on the inside diameter of the turn. If necessary, a corner can be molded with no appreciable radius on the side toward the mold, providing the tendency is to stretch the layers over the corner. Another solution is an extra thick corner from which the excess material is machined to give exact shape. In no case can a sharp corner be molded directly on a surface next to a flexible bag.

A special problem in corners arises with flanges. External flanges are easily made but internal flanges are difficult. With some materials, such as phenolic-treated fabric, a preformed flange can be incorporated as an insert in the final buildup. The insert may or may not be completely cured before the final bake.

Low-pressure molded parts are reinforced by better mechanical design or by the addition of special reinforcing materials. Better mechanical design includes such things as corrugation and ribs for strength and directional stability. Ribs and other transitions between thick and thin sections should be tapered, not abrupt.

Reinforcing materials molded into a part include metal shapes, wire and wire mesh, expanded sheet metal, wooden ribs, veneer face sheets and high-strength fabrics such as glass cloth. Sandwich-type construction with low-density materials molded between two sheets of laminated material gives high rigidity with light weight.

Beside adding strength, inserts can be used for electrical conduction, radio shielding, arc resistance, temperature resistance, thermal conduction, optical transmission, abrasion resistance and decoration. Nameplates can be printed on laminating material and assembled into the buildup before molding. Inserts that would normally be damaged in high-pressure molding can often be safely molded at lower pressures.

Small holes are best made by machining. Large holes should be made by leaving a somewhat undersize opening in the molded part and trimming the edges to size after molding.

Molded holes are a source of trouble because the hole in each layer of the buildup must index precisely. Often the hole will come in a spherically curved surface so that relieving gores must be cut around the hole to prevent puckering. Subsequent layers must be relieved at slightly changed positions so that the weakening cuts will not be concentrated in one location. When the buildup is complete, there is still the problem of keeping the layers from shifting during molding. Thus, it is possible, but not desirable, to mold finished holes.

Well-molded, low-pressure parts have a resin finish duplicating the mold. Smooth, hard mold surfaces give correspondingly smooth parts. A flexible rubber bag shows up all overlaps and wrinkles. Seams and other irregularities in the bag transfer impressions to the part. Therefore, if surface smoothness is critical, parts should be so designed that rigid mold surfaces can be used. For curved parts of regular contour, surface irregularities can be ironed out with a flexible metal separator between the bag and the part.

Because of adhesion between the mold and the surface of the part, a film of Cellophane or similar material is often required. However, folds and wrinkles in this film will be reproduced on the molded part. The film must also be completely removed before any paint or adhesive is applied to the part. Incidentally, molders recognize the desirability of not using a parting film and are working toward that end.

Molded finishes vary from mirror smooth to rough and fibrous. The first is desirable for streamlined surfaces. The second makes an excellent base for adhesion of glue or paint and is not objectionable if the part is to be machined.

Common surface defects of low-pressure laminates are blisters, wrinkles, insufficient resin, resin pockets or voids in corners, improper location of layers and foreign material. Molding defects are undercure; incorrect and non-uniform density; crushed, broken or torn fibers; and incomplete resin flow.

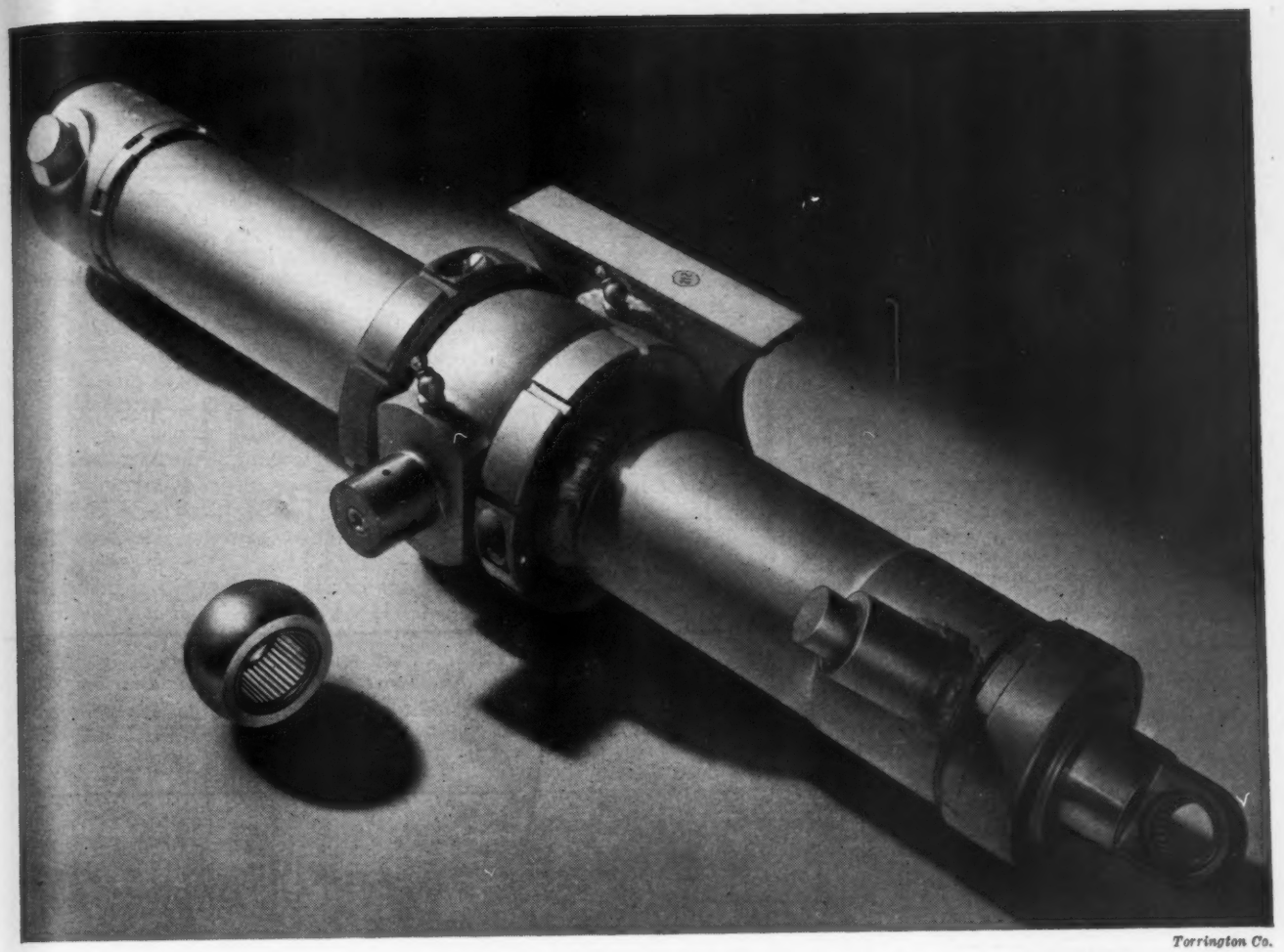
Wartime colors molded integral with the part are usually white, brown, or black, the shade varying with the amount of impurities and degree of cure. Colors and translucent parts are feasible.

Finishing operations on low-pressure laminates include all types of machining, assembly operations and surface coating. Typical machining operations include lathe turning, centerless grinding, drilling, fly-cutting, milling, thread-cutting and punching. Tools for mineral-filled laminates require special cutting edges.

Low-pressure molded parts and assemblies are made in sections and joined together when the size of the completed assembly is too great for existing molding equipment, the assembly is too complex and must be broken into simpler forms, mold design would be unsatisfactory for a single part or when the molding cycles or materials differ for each part of the assembly. Mechanical fastening or resin bonding is used for assembling parts. Either method also effectively joins a laminated part to other types of structural material.

Mechanical fastenings include standard items such as nuts and bolts, rivets, self-tapping screws, drive screws and spring clips. Glued joints are made on thermoplastic parts with solvent type cements. Thermosetting parts are joined with hot- and cold-set resin adhesive giving bonds as strong or stronger than the laminate.

Surface treatments can be decorative or functional. Little decorative work is done on war applications, of course, but surface treatments protect from weathering, serve to camouflage, pressurize or waterproof a container, provide electrical conductivity or reflectance to light or radio waves. All methods of painting, including dipping, are used, plus electrolytic plating, vacuum aluminizing and metal spraying.



Torrington Co.

Needle bearings used at knuckle joint and end connection of hydraulic cylinder in airplane landing gear.

Twelve General Considerations For Needle Bearing Applications

WALTER H. KORFF
Production Standards Engineer
Lockheed Aircraft Corporation

High load-carrying capacity and small space requirements are among the advantages of needle bearings for many applications. Limitations and differences in characteristics from other types of bearings are included.

PROPER application of needle bearings requires consideration of and familiarity with a number of factors, which can be classified and summarized under the heads: (1) Differences between needle bearings and roller bearings, (2) advantages and limitations, and (3) general considerations. Without this knowledge, or without familiarity with all considerations, the chances for success of any bearing design are better if the aid and experience of men who specialize in bearing problems are enlisted.

Differences Between Needle Bearings and Roller Bearings

1. Rolling elements of needle bearings are smaller in diameter in relation to the shaft, and they are longer than roller bearings. Their needlelike appearance gives them their name.

2. Rolls of roller bearings are held in a retainer while the needles are not.

3. Needle rollers do not turn at a speed proportional to the ratio of the shaft diameter to the needle diameter. Slippage occurs which varies with speed

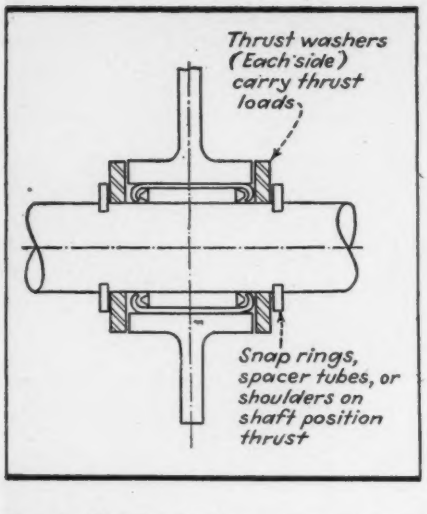


Fig. 1—Needle bearings cannot carry thrust loads. Such loads are taken by thrust washers or other means.

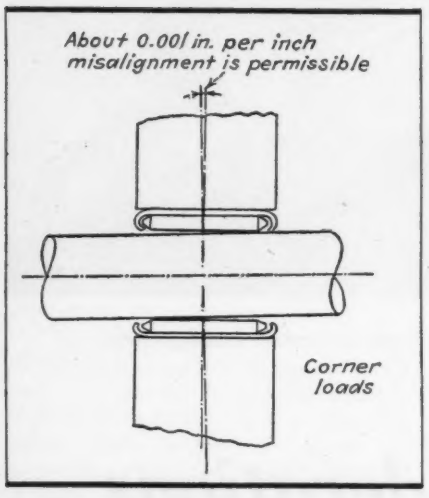


Fig. 2—Corner loading is caused by excessive misalignment. Ends of the needles then contact the shaft instead of making uniform contact along the needle length. Needles then spiral on the shaft, lock the shaft, and prevent rotation.

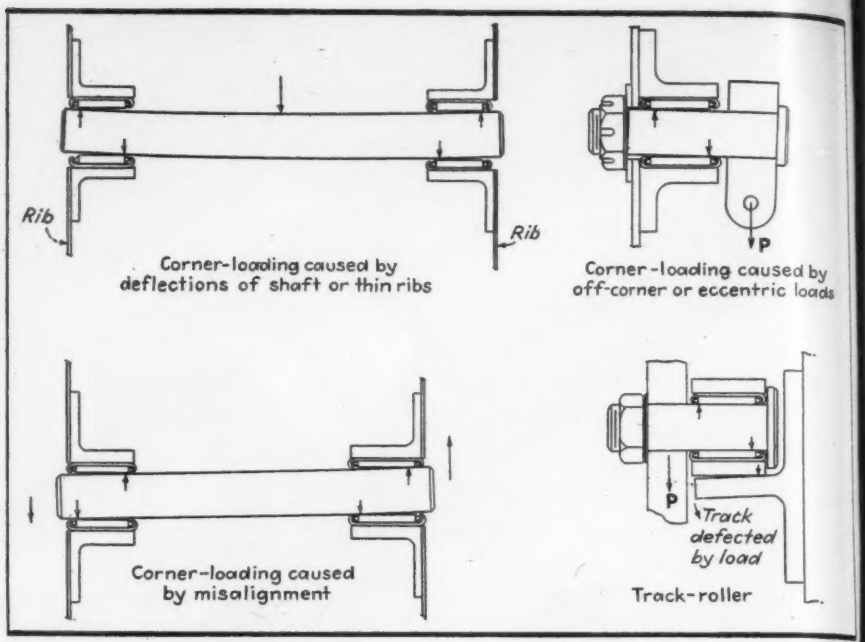


Fig. 3—(Above) Four causes for corner loading on needle bearings.

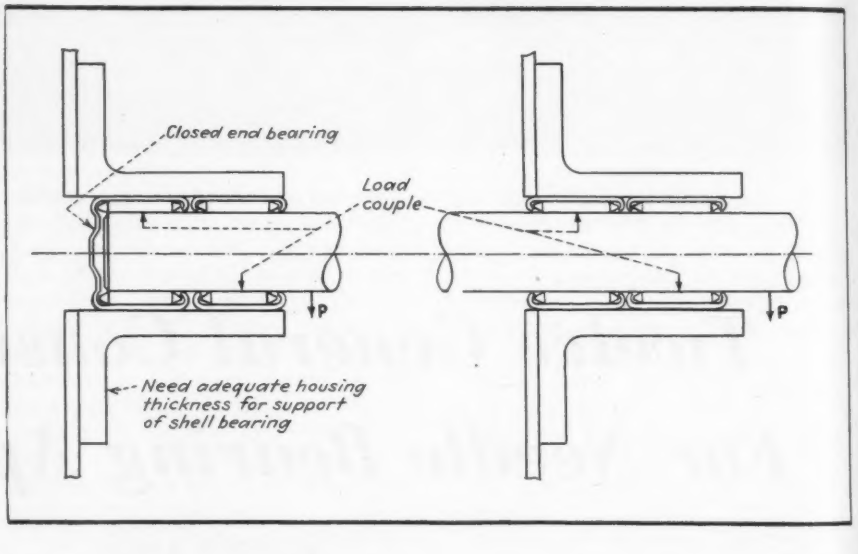


Fig. 4—(Below) Corner loading can be avoided by mounting two short bearings end to end so that couple loads are divided and distributed.

and load conditions. For this reason, lubricant must always be between the needles and the shaft.

Advantages of Needle Bearings

1. CAPACITY. Size for size, needle bearings have the greatest load-carrying capacity of any type of anti-friction bearings.

2. COST. Needle bearings cost less per given load than any other type of anti-friction bearing.

3. SIZE. Generally speaking, needle bearings require no more space than a plain bushing.

4. FRICTION CHARACTERISTICS. The starting or "breakaway" torque of needle bearings is practically no greater than their rolling friction. The coefficient of friction is somewhat less than that of plain bushings. The shape and structure of needle bearings provide a well-sealed lubricant reservoir. Needle rollers maintain a constant oil film between the bearing and the shaft. This permits a low starting torque and prevents spalling on the shaft.

Limitations of Needle Bearings

The limitations of needle bearings, as compared with roller bearings, are inability to take thrust loads and difficulty in preventing "corner loading" or load concentrations on ends of needles.

1. Thrust loads, if present, must be transmitted from the shaft to the housing by means of thrust washers, as in Fig. 1. This can be accomplished simply, requires little space, and is important to the satisfactory functioning of the bearing. Even the end washers of some types of needle bearings should not be expected to take thrust loads.

2. Corner loading, which is illustrated in Fig. 2, is caused by an off-center or cantilever load, or a misaligned bearing. A couple is produced within the bearing, which applies a load at one end of one roll and at the opposite end of the roll diametrically opposite. This skews the needles and rotation of the shaft spirals them around the

shaft. The bearing then creeps along the shaft. If the rotation is reversed, the bearing creeps along the shaft in the opposite direction.

If corner loading is reversed, either by reversing the direction of the load or by reversing the misalignment of the bearing and shaft, the bearing creeps in the opposite direction. Corner loading is not restricted to needle bearings however; it can occur in roller bearings as well. Generally speaking, four causes, which are illustrated in Fig. 3, are: 1. Misalignment of bearing and shaft resulting from excessive manufacturing tolerances. 2. Deflections of shaft or housing supporting structure. 3. Reversal of loads which prevents needle rollers from realigning themselves. 4. A thrust load or a radial load applied in any manner except normal to the axis of the bearing.

Deflection is the greatest offender in airframe applications. Airframes are expected to deflect, and will if a favorable weight to strength ratio is achieved. By contrast, mechanisms that are surrounded by husky castings and utilize short heavy shafts have negligible deflection. However, needle bearings can be used successfully where there is considerable deflection.

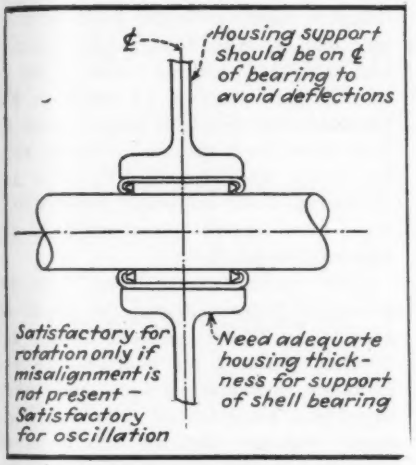

℄
Housing support should be on ℄ of bearing to avoid deflections
Satisfactory for rotation only if misalignment is not present — Satisfactory for oscillation
Need adequate housing thickness for support of shell bearing

Fig. 5—A single thin-shell bearing can be used in a flexible structure by reducing diameters of shaft and housing.

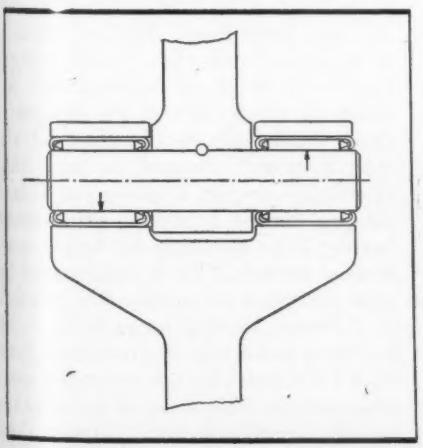


Fig. 6—For best loading conditions in tongue and fork bearings, such as in aircraft engine connecting rods, bearings are put in the fork.

The solution of the deflection problem is to use two short bearings mounted end to end on a large tubular shaft as in Fig. 4. Couple loads resulting from misalignment or deflections are then divided between the two bearings and applied midway on the length of each bearing. A single bearing can be used in a flexible structure if shaft and housing diameters are reduced. This practice should be governed by a qualified bearing engineer because it is not standard practice and bearing manufacturers cannot otherwise guarantee the success of the design. Generally, about 0.001 in. per in. misalignment is permissible on typical single-bearing applications such as in Fig. 5.

If the bearing oscillates and load is applied only in one direction, corner loading is not serious. Needle rollers under load will skew and spiral on the shaft, but since the shaft oscillates, it will spiral the rollers back to their original position when the direction of rotation is reversed, if the load remains in one direction.

When loads are reversed with oscillating motion, as in a connecting rod on a four-cycle engine, the bearings should be in the fork, not the tongue, as illustrated in Fig. 6. This is good general practice for any tongue and fork application because it prevents couples created by any loading condition, including misalignment of parts, transmission of torque or torsion, and other conditions.

General Considerations

There are 12 general considerations that have important effects upon operation of needle bearings:

1. Shell-Type Outer Race. Thin shell-type bearings are not self supporting. The shells only supply a hard surface to the outer housing and retain the needle rollers in the assembly. Since shells go out of round during heat-treating, they must be backed by a housing with sufficient wall thickness to maintain a true round under load. The housing is an essential part of the bearing assembly.

2. Hoop Tension in Thin-Walled Housing. Inasmuch as the shell is an interference fit in the housing, design of thin-walled housings must be based on hoop tension rather than bearing loads. In some instances where hoop tension has been neglected, thin-walled housings have cracked or failed completely when bearings were pressed in place.

3. Housing Fits and Shaft Fits. The housing fit of a needle bearing is always an interference fit. The amount of interference is important to successful operation of the bearing. Bearings are so designed that the needles have a certain amount of freedom in the unloaded zone to realign themselves. Either insufficient or excess interference fit disturbs the relationship of the needles to the shell, the shaft and themselves. A common error is to use the fits listed for steel housings in aluminum housings and vice versa. This condition is critical in any type of bearing and is most critical in needle bearing applications.

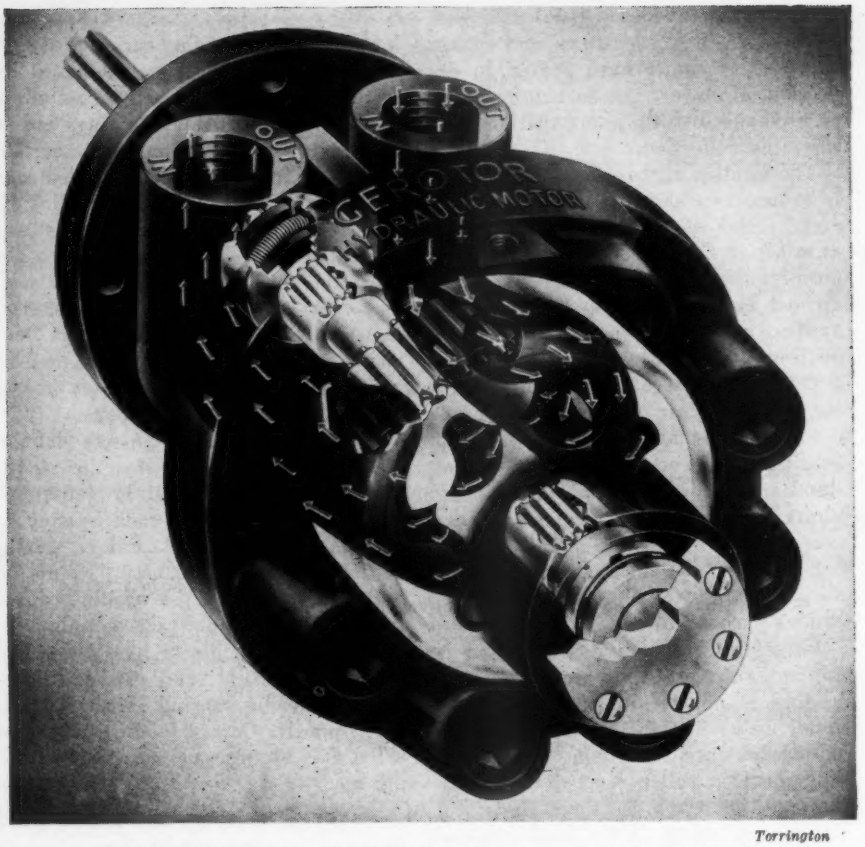
Likewise, needles require a definite clearance relationship to the shaft. Recommended high and low shaft dimensions, as listed for each bearing in bearing manufacturers' catalogs, should be used. If sufficient accuracy cannot be obtained on the shaft, a needle bearing that has its own inner race should be selected. It is possible to have the housing fit and shaft fit "out" enough to prevent the needle bearing from functioning properly. Corner loading is aggravated also by improper shaft and housing fits.

4. Shaft Hardness. The hardness of the shaft on which the needles roll must be at least Rockwell C 52 when used with regular bearings and Rockwell C 58 for extra capacity bearings. The aircraft industry uses X-4130 steel, normalized, which Brinells at less than 5 percent of rated capacity of the bearing.

5. Chrome-Plated Shaft. Chrome plating should never be used as a method of achieving a hard surface for shafts on which needles are to roll. Chrome plating does not deflect at the same rate as the steel shaft under it, and the severe "kneading" action of the needles causes the chrome plating to break and flake off.

6. Oil Hole Problems. Normally, additional lubrication is not required. Needle bearings are effectively sealed and come packed with low-temperature lubricant. At high-speed operation, however, it is best to feed a limited amount of oil slowly through an oil hole. In extremely dirty applications, as when exposed to the direct blast of an airplane propeller, it is possible to drive minute gritty particles under the seals. In such applications it is recommended that a grease fitting be used. Greasing then forces the old lubricant out through the seals, carrying foreign matter such as grit or water with it.

The lubricant hole should be located in the "no load" zone of the bearing. An oversize hole in the housing allows for installation errors. If a groove must be used, bearing capacity must be reduced accordingly. Sometimes, to sim-



Torrington

Fig. 7—Different sizes of needle bearings are used in this hydraulic motor. Cutaway views show the location of three needle bearings.

plify production, it is convenient to groove the housing all the way around at the oil hole. Then, no matter how the bearing is installed, the lubricant hole is fed from the groove. If this is done, the groove reduces the area of bearing support and the load rating of the bearing must be reduced in direct proportion to the length of the needle.

7. Track Rollers and Load Ratings. Track roller bearings require thicker outer races than are employed in bearings backed up by rigid housings. Bearing catalogs list "track roller" bearings, which are designed with inner and outer races having sufficient strength to carry the loads listed for them.

Care must be exercised to insure that the parts adjacent to the track roller are adjusted to deflect proportionally, thus insuring a uniform track-to-roller contact; otherwise, a concentrated load of sufficient magnitude to rupture the roller could be applied to the roller.

Track hardness and strength must be adequate. A Brinell mark on the track can create a serious concentrated load condition. Errors in adjustment of deflection can be compensated by a slight curvature in the outside diameter of the roller face. A 3-in. radius for a 1½-in. diameter roller is about right.

Load ratings of track rollers are expressed in three ways: (1) Track capacity, (2) rolling capacity, and (3) non-Brinell capacity. Track capacity is the maximum carrying capacity of the track at a fixed hardness, generally taken at 180,000 lb. per sq. in. Rolling capacity is an indication of the load that can be put on the bearing and track without undue increase in the coefficient of friction. High loads, deflection and other conditions cause the coefficient of friction to become unpredictable. Track and rolling capacity indicate life expectancy, a figure in the order of 10,000 cycles. Non-Brinell capacity is the maximum static load a bearing can carry without seriously Brinelling the races of the bearing.

8. Staking. The outer race of a thin-shell needle bearing should not be staked to the housing. Its interference fit will hold it. Staking may damage the thin shell. Thick-race heavy-duty bearings may be staked when installed with a slip fit.

9. Bearing Tests. If the success of an installation is in doubt, an accelerated endurance test based on the required service life of the installation should be run; not just a functional test. Sometimes a bearing design that does not meet recommended bearing practice must be risked. Usually, in such instances, a functional test appears to be satisfactory. After the bearing is in use it may prove to have a short service life and require frequent replacement. An accelerated endurance test would have determined whether or not the service life would have been acceptable.

10. Bearing Capacity. It is a common but erroneous practice to use the static non-Brinell rating when the bearing operates at low speed (10 r.p.m. for example) or with oscillating motion. Static non-Brinell capacity applies only to the maximum load that can be put on a static bearing. Any motion, however slight, greatly reduces the load capacity. Two-thirds of non-Brinell capacity can be used as working capacity for aircraft bearings. For rapid oscillation, the load that applies for 500 r.p.m. should be used. Bearings specifically designed for oscillating should be carefully avoided for rotating motion because internal clearances do not permit proper operation. R.p.m. should be calculated accurately, using load values listed for the bearing at that speed.

11. Relative Load Ratings for Competitive Bearings. Two bearings of different manufacturers, but otherwise identical in size, design and material and heat-treatment, have been found to vary in load capacity as much as 300 percent. One bearing may appear to have three times the load carrying ability of the other. Small differences are understandable, but such great differences often appear unreasonable to design engineers.

Close examination shows that the great differences depend on depth of acceptable Brinell, which is not accurately defined, on bearing life expectancy, operating r.p.m., and other variables. Experienced bearing engineers evaluate carefully the required operating factors of a bearing installation and apply correction factors to each bearing manufacturer's values, thus achieving balance in satisfactory operation, service life, weight and cost.

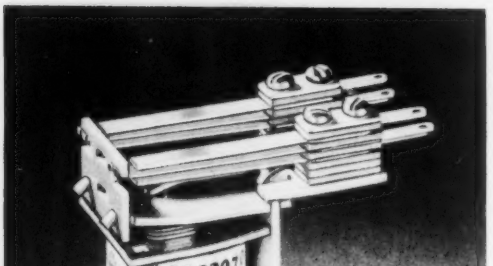
12. Life Expectancy. Military aircraft, as a general rule, have little bearing trouble in air-frame applications because the service life of the aircraft is short. Service life of a commercial aircraft frequently exceeds ten times that of military aircraft. Engineers now face the problem of predicting still longer bearing life expectancy for larger commercial aircraft. This is complicated by wide variations in published life values of different bearing manufacturers. It has been noted that this variation runs from 2,500 hours for one reputable manufacturer, to 10,000 hours for another equally dependable manufacturer. Others vary widely between these. Therefore, any bearing choice, to be completely engineered, must deal with this variable.

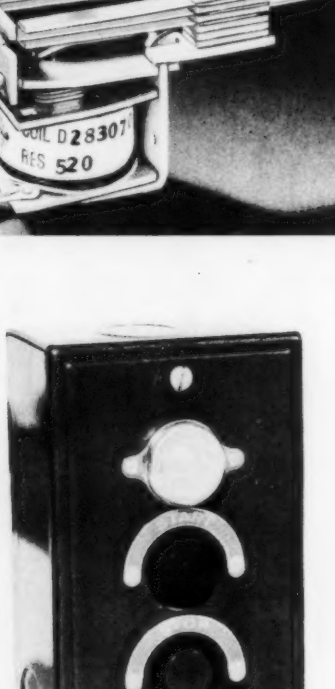
Electric Controls

FOR PRESENT AND POST-WAR PRODUCTS

An editorial summary of developments in electric controls for industrial, domestic and aircraft accessory applications, with reference to mechanical and electrical characteristics.

Developments in Electric Controls





Advances and improvements in the design of electrical control devices and their manifold uses in place of manual and mechanical controls are striking examples of the rapid progress made by science and engineering in war-time.

Electrical control replaces numerous working parts, eliminates friction drag and lost motion, gives instantaneous or delayed response as desired, thus saving time and materials.

Electric-hydraulic automatic pilot systems have been developed that can take over the controls of an airplane, maintain the course set by the aviator, and relieve him of the duty of controlling the flight. Any pitch, roll, or yaw of the airplane causes a signal from electric pick-offs associated with special gyroscopic instruments. The signal is amplified, operates valves, causing hydraulic power to move the control surfaces to bring the airplane back to its correct altitude and course.

Automatic temperature control has been devised for engine heads, oil coolers, and similar applications on large aircraft. Midget temperature-sensitive elements fitted into the engine head, operate sensitive relays to open or close ventilating shutters as required.

Relays installed in aircraft wiring circuits between the control point and the load limit the wiring between these points to the relay coil control wires, thus elminating long runs of heavy wire.

Bouncing and chattering in electrical relays have been eliminated through the use of hollow contacts partly filled with metallic powder.

Electronic Control Applications

Close coordination of electrical and mechanical design has made possible the successful use of electronic control in many applications. Only by this cooperation has it been feasible to insure that the electrical and mechanical equipment will match each other in precision and reliability.

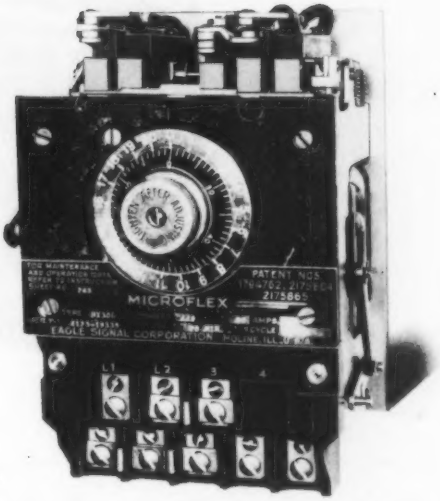
Photo-electric control is used in many new applications for actuating systems in response to changes of color, shade, density, shape, or position without mechanically touching the controlling object.

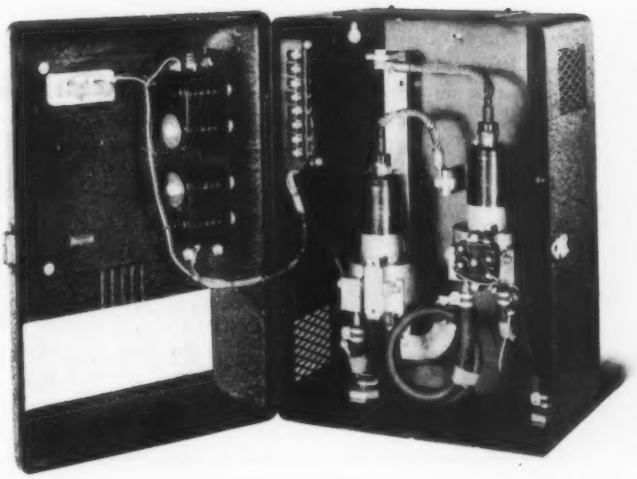
Electronic control, both synchronous and non-synchronous, has been widely adopted in resistance welding because of reduced maintenance at high operating speeds and also because of the precision obtainable.

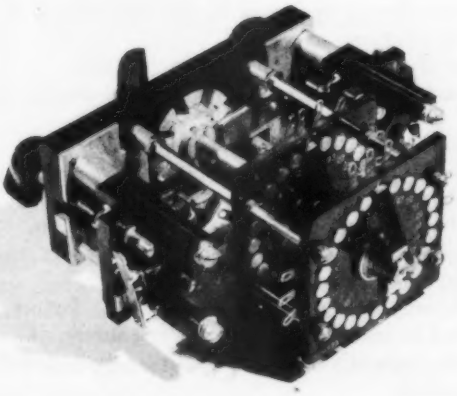
Electronic switches use the enormous amplification available from a vacuum tube to achieve performance characteristics not possible to approach with electro-mechanical relays or limiting switches.

Motor drive problems of many types are best solved by using the characteristics inherent in a shunt wound d.c. motor. But the relative unavailability of d.c. power has made it difficult to use a d.c. motor. To fill this need, electronic controls have been developed which operate d.c. motors from a.c. lines, thus making available many desirable drive features.

Automatic starting, stopping, changing of speed, and cycle timing of chemical processes and production machinery can be controlled with a new development that makes use of printed charts which can be replaced or interchanged as readily as phonograph records.







Arrow-Hart Hegeman Electric Company

Safety Pull and Push Switch

Start and stop operations are performed with one button. Pull on button closes circuit. Push on button opens circuit.

Motor is stopped if button is accidentally hit or pushed.

Normal position of button is in the center.

Switch units are built into molded plastic blocks. Units can be mounted in vertical or horizontal gangs.

Series of styles provides for three methods of operation:

1. Momentary contact, pull-push or pull only.
2. Maintained contact, pull-push in double or single pole and 2-circuit positions.
3. Combination of momentary and maintained contact; pull-push, turn button to maintain contact.

Switches are rated at 600 volts, a.c., maximum.

Midget Snap Action Switch

Rolling spring, non-friction action, provides flexible positive operation.

Spring flexibility permits using steep pressure angles to obtain high contact pressure.

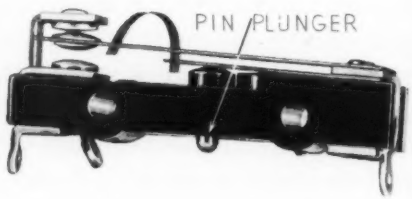
Pressure angle is practically constant until force, about four to six ounces, on pin plunger overcomes resistance of the rolling spring, then actuating blade passes through dead center and causes rolling spring to carry the contact blade with a snap action to one contact position. Operation in the opposite direction takes place when pressure on the pin plunger is reduced to two to four ounces.

Blade is of one-piece split construction, without bearings or knife edges.

Through bolts are soldered on both ends with aircraft type terminals.

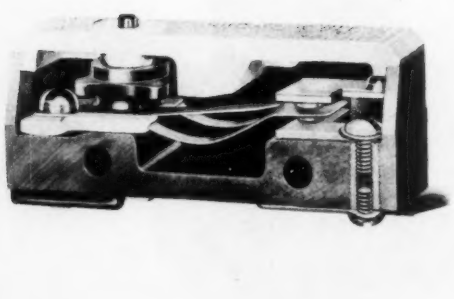
Single pole, normally open, normally closed, and double throw types are available.

Switch is rated at 1,000 watts a.c., 10 amp. at 115 volts a.c., 5 amp. at 250 volts a.c., and 3 amp. at 450 volts a.c.



Acro Electric Company

Small Precision Switch



Micro Switch Corporation

Snap-acting mechanism is a one piece, three-bladed, beryllium copper spring.

Two short outer blades of spring are compressed and pivot in a grooved brass anchor. Center blade of spring is fixed in mounting to form a cantilever.

Spring flexes during operation in the same direction of motion as the operating plunger.

Overtravel of plunger cannot reopen contacts.

Flat stationary contact and curved movable contact are usually of fine silver.

Terminals are brass, tinned to facilitate soldering.

Stainless steel pin operating plunger has a plastic molded head to prevent electrical leakage from live parts.

Operating pressure differentials range from ¼ to 4 ounces, and operating movement differentials from 0.0002 to 0.040 inches, depending upon type of switch and actuator.

Housing is molded of plastic material. Holes for mounting screws are jig drilled to insure accurate center distance.

Single pole, normally open, normally closed, and double throw types are available.

Switch has an a.c. rating of 10 amp. 125 volts, 5 amp. 250 volts, 3 amp. 460 volts, and 2 amp. 600 volts.

Instruments Show Operating Conditions

Interchangeable voltmeters, ammeters and wattmeters give readings of loading conditions.

Blades on back of instrument plug into jaws in socket mounting thus automatically completing all connections.

Threaded outlets on socket for receiving pipe conduit.

Solderless type terminal blocks in socket.

Annealed glass cover, held to base plate with metal band, protects instrument.

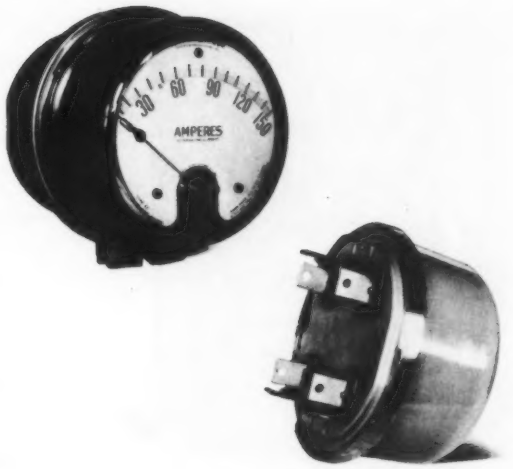
Grooved ring, fitting over flanges on instrument and socket, makes the entire unit dustproof and weatherproof.

Special alloy, heat-treated springs assure accuracy and permanence of calibration.

Permanent magnets are formed from tungsten steel.

Light weight vanes for damping operate in closed dustproof chambers.

Overload capacity, sufficient to carry starting inrush current, permits leaving instrument in the circuit while motor is started.



Westinghouse Electric & Manufacturing Company

Timing Motor and Gear Unit

Haydon Manufacturing Company, Inc.

Shaded coil motor construction gives high starting torque.

Projection welded motor field structure assures accurate air gap.

Two porous bronze graphite bearings filter lubricant from sealed reservoir to bearing surfaces of rotor shaft.

Capillary lubricating plate carries lubricant to each gear assembly irrespective of mounting position.

Tin plated gears and motor shaft housing prevent oil oxidation.

Gear housing is solder sealed to exclude dust and moisture.

Output shaft speeds range from 450 r.p.m. down to one revolution in 1,000 hours depending upon gear trains.

Operating frequencies range from 25 up to 120 cycles at voltages up to 250 volts.

Automatic reset type timing motors have magnetically operated counterbalanced gear shift for use with external spring to reset drive shaft.

Magnetic brake can be furnished for stopping the rotor instantly when current is turned off.

Friction drives can be added which permit turning the drive shaft in either one or both directions independently of the gear train or motor.

Close Control Rheostats

High strength ceramic hub insulates shaft and bushing from all live parts.

Vitreous enamel bonds the core and base into one unit.

Resistance wire is wound over a solid porcelain core. Each turn is locked against shifting by vitreous enamel.

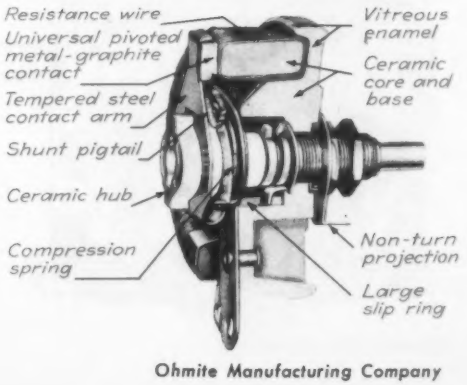
Metal-graphite contact brush rides upon flat surface. Flush floating brush contact is obtained with pivot mounting.

Slip ring carries current from brush pigtail to terminal connection. Three terminals are provided so that rheostat can be used as a potentiometer or voltage divider.

Tempered steel contact arm forms a long steel spring to provide uniform contact pressure.

Stops, keyed to shaft and base, limit rotation and protect contact arm form torsional strain.

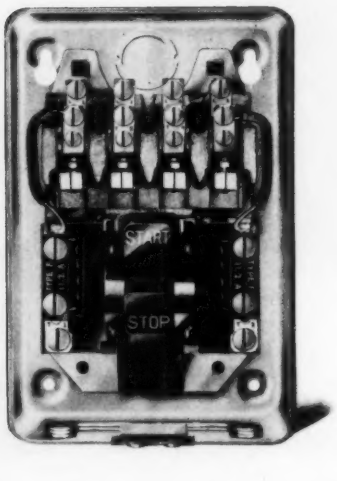
Compression spring maintains uniform pressure and electrical contact between slip-ring and centerlead, independent of pressure at brush.



Ohmite Manufacturing Company

Start and Stop Controls

Across-the-Line A.C. Motor Starter



Colt's Patent Fire Arms Manufacturing Company

Toggle mechanism is in the latched position at all times, except when momentarily tripped by an overload.

Relatching after tripping is automatic.

Bimetallic latches, an integral part of switch mechanism, with inverse time limit characteristics give overload protection. Heater elements for actuating the latches are available in a wide range of ampere ratings.

Circuit is restored, after overload has been cleared, by depressing start button.

Free handle design permits starter to open circuit during overload even though handle is held in the "on" position.

Silver contact buttons welded to bronze supports reduce contact resistance and heating.

Heat and arc resisting qualities are obtained by using blocks molded of a cement base with asbestos filler and inorganic binder, then impregnated to obtain low moisture absorption.

Flashover across phases is prevented by overlapping barriers or arc shields between each set of contacts.

Steel backplate, on which complete unit is assembled, can be removed from cabinet by loosening one screw to facilitate wiring.

Slotted end of movable contacts fit under disks in block.

Manual Starter for A.C. Motors

Arc quenchers confine and extinguish arc in less than 1/100 second, decreasing flashovers and flames thus lengthening life of silver contacts.

Porcelain arc box prevents carbonization and eliminates surface creepage.

Grids for each phase break the arc into a series of small arcs, increase the rupturing capacity and reduce burning of contacts.

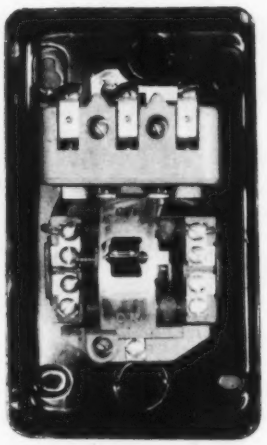
Snap-action, preformed disk-type, bi-metal relay upon sustained overload in motor circuit trips latching mechanism to open switch.

Overload will trip out starter even though handle is held in "on" position.

Interchangeable heaters for the overload relays include a wide variety of ratings to provide accurate overload protection.

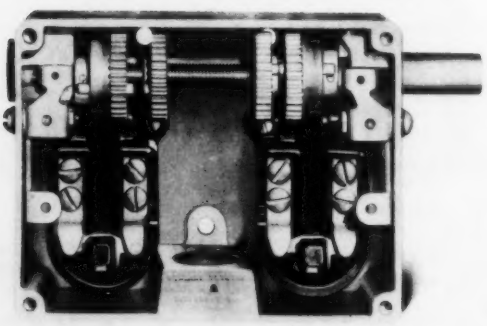
Inverse time limit provides ample time for starting with full motor protection.

Positive mechanism eliminates "teasing" when motors are jogged.



Westinghouse Electric & Manufacturing Company

Rotating-Type Limit Switch



General Electric Company

Limits the number of rotations of a motor driven shaft, gear, or machine.

Mechanism is adjustable for operation of contacts between ½ to 120 turns of switch driving shaft.

Adjustment is made by depressing a lever which releases the shaft on which the travelling gear is mounted, then rotating travelling gear to required position.

Overtravel, after switch has been tripped, of 3½ turns is provided before switch has to be reset.

Rocking motion of contact arms, when opening and closing circuit, keeps silver contacts clean.

One double-break contact assembly is built into switch at each end of travel. Switch can be made normally open or normally closed with same contacts.

Noncorrodible, dustproof die-cast case protects mechanism.

Mountable in any position to suit attachment to drive shaft.

Electronic Time Delay Relay

Provides a time delay after a contact or initiating switch is closed, and which is allowed to remain closed for the duration of the time setting.

Control circuit can be either opened or closed, at end of elapsed time, depending on the manner in which the contacts and initiating switch are connected.

Telephone type relay closes control circuit.

Length of time delay is adjustable, about a 20 to 1 ratio, between maximum and minimum time. Maximum time ranges from 0.9 to 140 seconds depending upon rating of timing resistor and capacitor.

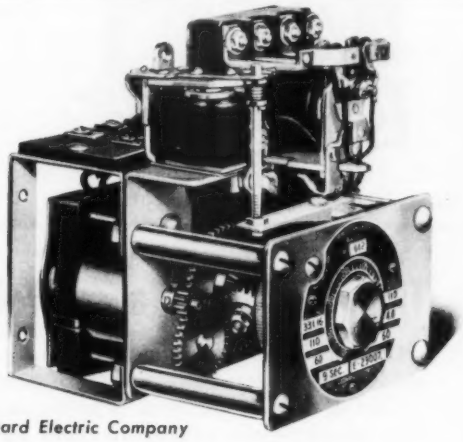
Time adjusting knob is outside of front cover, and mounted on potentiometer shaft extension.

Relays operate on 115/230 volt, 60/50 cycle alternating current.

Vacuum tube, time delay relays are used for processing, cycling, sequencing, limiting, delaying, and resetting operations in such applications as

Welding machines	Honing machines
Molding machines	Process furnaces
Centrifuge control	Sign Flashers
Machine tools	

General Electric Company



Ward Leonard Electric Company

Motor Driven Time Delay Relay

Adjustable time delay is provided after closing of a pilot circuit.

Relay consists of a synchronous motor, a differential gear system, a magnetically operated brake, a trip switch assembly, and an auxiliary relay.

Auxiliary relay is energized at end of the selected time, which makes or breaks the load circuit as desired. Relay remains energized until recycled by breaking the pilot circuit.

Locking device prevents any unintentional change in the time setting.

Timing ranges are available varying from 3.5 seconds to 6 minutes minimum delay, maximum delay is ten times minimum. Relay motors are designed for operation on alternating current.

Pneumatic Time Delay Relay

Time delay is dependent upon the transfer of air through a restricted orifice into a chamber sealed with a neoprene-fabric diaphragm.

Timing range is regulated by position of adjustable needle valve. Range of adjustment is from 0.2 second to 3 minutes.

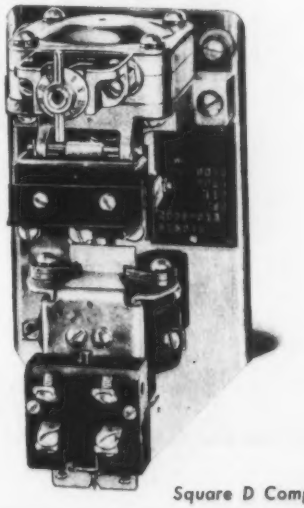
Magnetic contactor mechanism actuates a spring loaded contact operating block.

Operation is started when the force acting on block is removed by either energizing or deenergizing the magnet coil depending upon timer arrangement.

Contact mechanism is operated through a pivoted lever which is depressed by the block when near the end of its travel.

Mechanism can be reset instantaneously at any time during or following the timing period.

Energization and de-energization of actuating magnet may be effected by pilot control devices such as push buttons, limit switches, thermostats or timing mechanisms.



Square D Company

Time Interval Control

Timed Stop-Cycle Control

Synchronous motor in instrument assures exact timing. Motor is lubricated for life.

Vernier adjustment gives settings to a split-scale division.

Hum is eliminated and releasing is improved by use of shading coil with solenoid.

Thrust of cone clutch when engaging or disengaging is absorbed by ball thrust bearings.

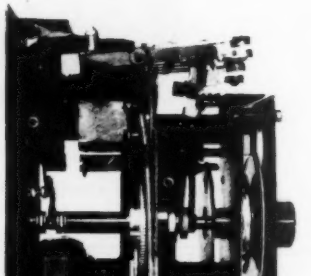
Corrosion resistance of ferrous parts is improved with a black dye-treatment.

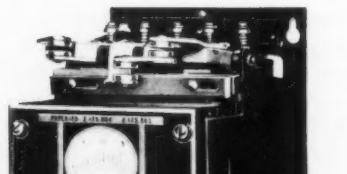
Circuits for motor-clutch and load can be wired together by placing a jumper across two terminals.

Three color-coded slides provide manual selection of desired connections to suit different operating conditions.

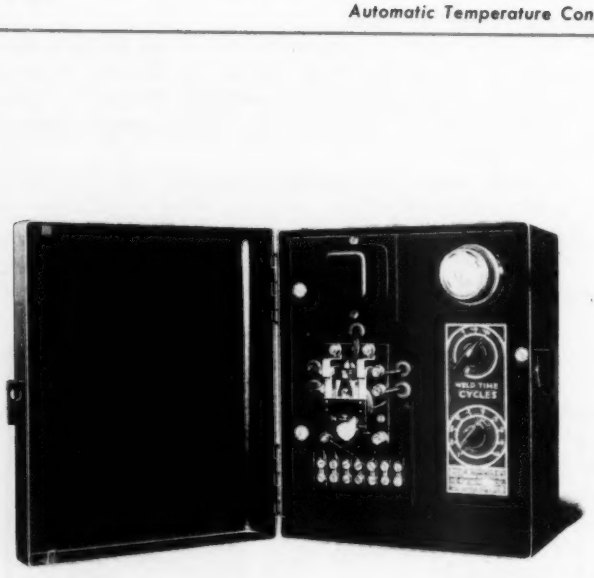
Industrial applications for timed stop-cycle control include:

Molding presses	Automatic mixing
Die-casting machines	Cutting machines
Automatic lubrication	Elevator control
Battery charging	Deep well pumps
Automatic weighing	Continuous furnaces
Alarms and signals	Baking ovens





Automatic Temperature Control Company, Inc.



Clark Controller Company

Timer for Resistance Welder

Controls closed time of a magnetic primary welding contactor while a resistance weld is made.

Control of time duration is accomplished with two pointer knobs which turn over index dials, one for coarse adjustment and one for fine adjustment.

Time settings from 2 to 30 cycles based on a 60 cycle circuit are adjustable in 30 steps.

Device uses only one electronic tube and one relay. Other units in circuit have no moving parts.

Timer operates from a 110 or 220 volt, 60 cycle source separate from welding power line. This eliminates effects of voltage dip, caused by main welding load, from interfering with the proper operation of the main contactor and welding timer.

Tests indicate that on a 10 percent voltage increase more than normal a timing decrease of about 2 percent should be expected, on a 10 percent voltage decrease a timing increase of about 4 percent is obtained.

Timer can be used on manual, air, or motor operated welders which have a maintained contact type initiating switch.

Electronic Control of Speed

WITH A D.C. MOTOR AND AN A.C. SOURCE

System consists of a single or polyphase grid controlled thyratron tube rectifier, which takes power from an a.c. line and rectifies it into d.c. output.

Rectified current is applied to armature and field circuits of a shunt wound d.c. motor.

Potentiometer in control station varies the voltage of the rectified current by shifting the phase of the grid control voltage of the thyratron tubes.

Armature voltage can be varied from zero to more than rated voltage of motor.

Field voltage can be held constant throughout the range of armature voltage and then be reduced to provide increased speed range by field weakening.

Crackle-finish cabinet incloses tubes and equipment, or they can be installed directly in the driven machine.

Speed variation, starting, stopping, reversing and current limiting controls are on the control station.

Stepless range of d.c. motor speeds is obtained from an a.c. source.

Starts motors and brings them up to a preset speed smoothly and rapidly.

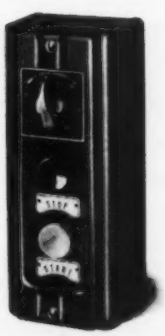
Speed of motor can be changed at any time.

Automatic close speed regulation is provided over wide load fluctuations.

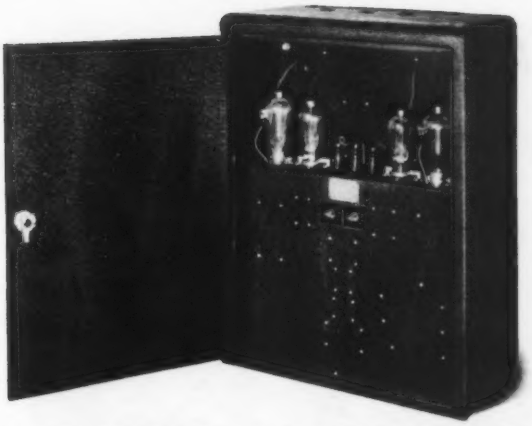
Constant torque can be obtained from zero to rated motor speed.

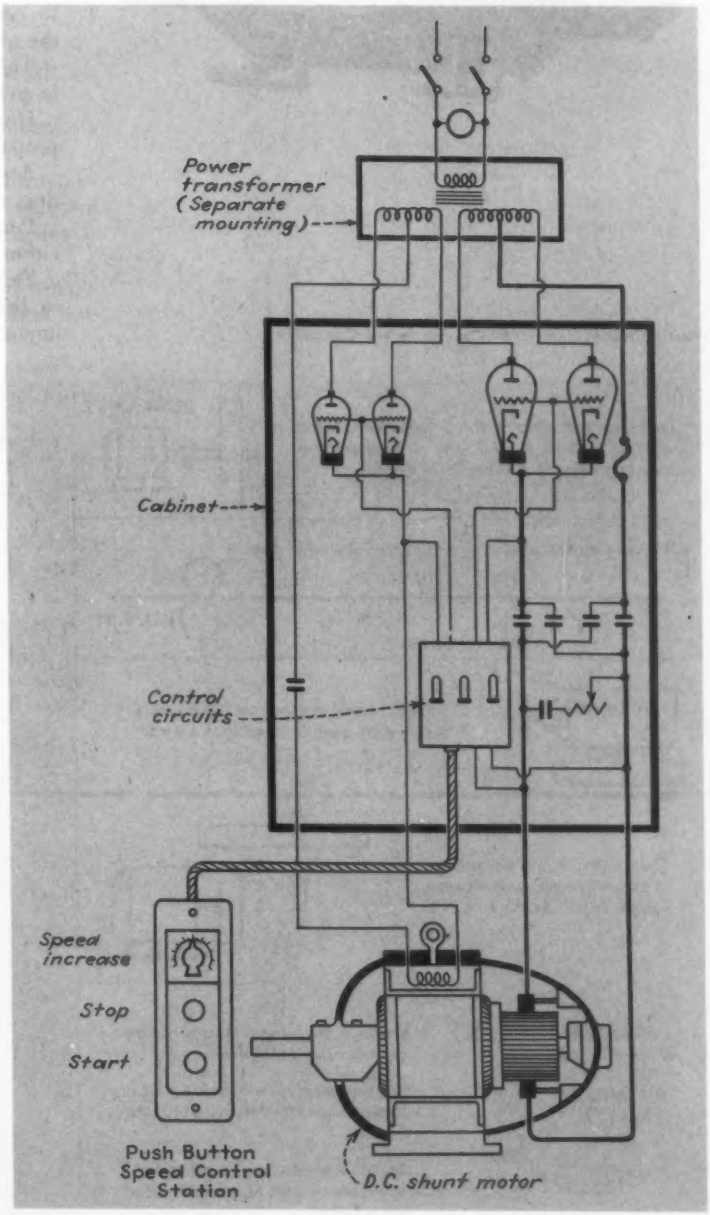
Constant horsepower can be obtained from base speed to higher speeds.

Starting shock and line current peaks are eliminated by limiting acceleration current.



Westinghouse Electric & Manufacturing Company





D. C. Adjustable Speed Drive Control

Westinghouse Electric & Manufacturing Company

Controlling unit is essentially a small d.c. generator. It makes possible a wide d.c. motor speed range, close regulation, accurate speed control, acceleration and deceleration control, and the following of an established pattern.

Magnetic circuit of unit is excited by a number of field windings which are designed and connected in various ways to suit the regulating problem.

Unit functions entirely through the interaction of these fields without the use of vibrating relays, contactors, or delicate moving parts that require careful adjustment.

Armature is driven at constant speed either as a part of a main motor generator set or as a separate exciter set.

Self-energizing field supplies necessary field strength to furnish the required armature output.

Field coils constitute the control or input circuits used to compare standard and actual values representative of the quantity to be regulated such as:

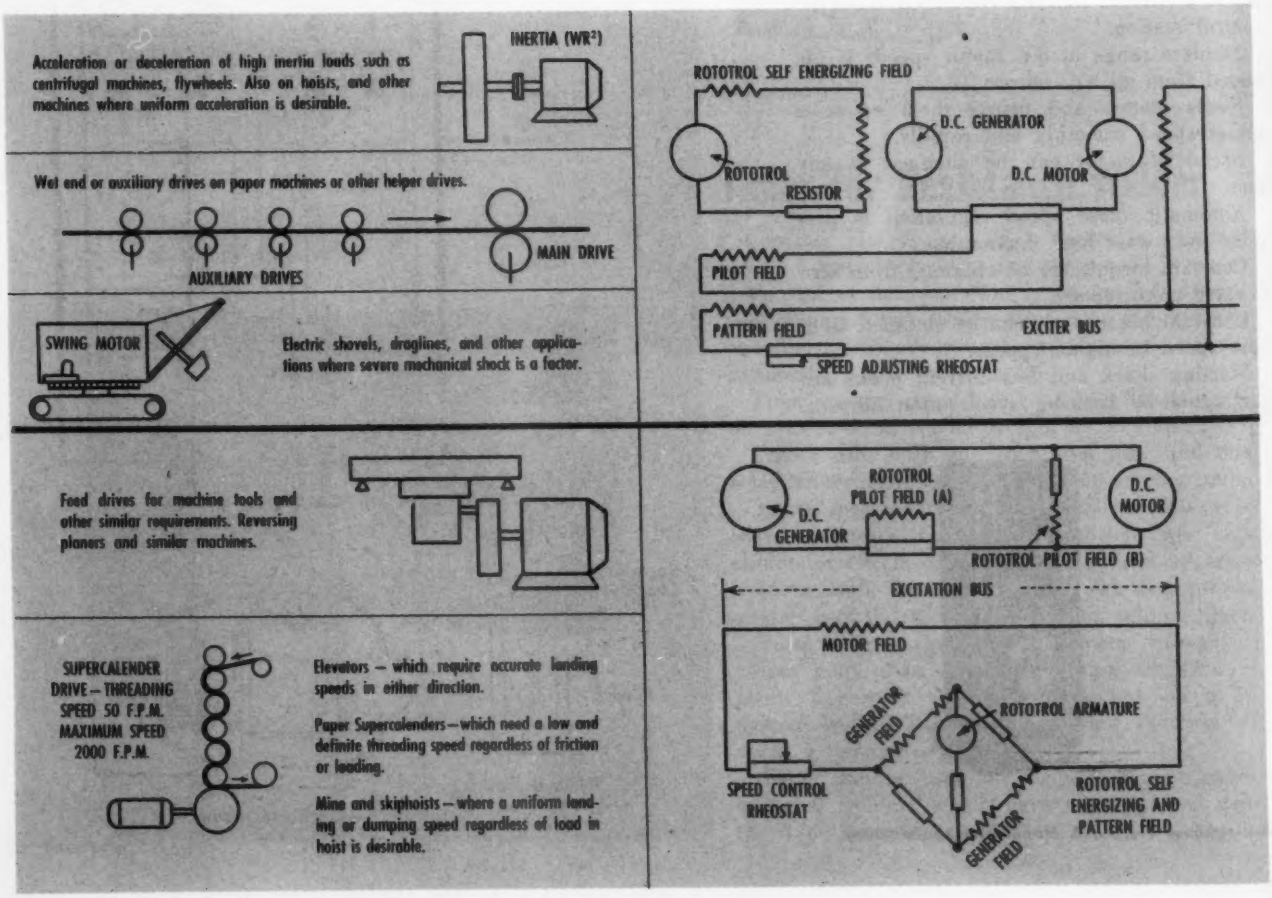
Torque of a d.c. motor with constant excitation which is proportional to the armature current.

Horsepower of an adjustable speed d.c. motor which is proportional to the armature current.

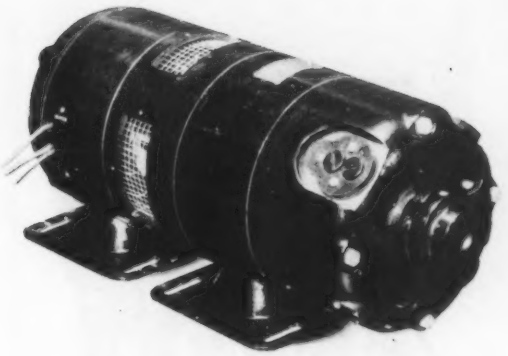
Accelerating force which depends on the torque and thus on the current of a d.c. motor.

Performance of the motor is accurately indicated by either armature or field current or both.

Fields of control unit can be proportioned and polarized so that each quantity measured can be given its proper importance in the magnetic circuit.


Acceleration or deceleration of high inertia loads such as centrifugal machines, flywheels. Also on hoists, and other machines where uniform acceleration is desirable.
INERTIA (WR²)
Wet end or auxiliary drives on paper machines or other helper drives.
AUXILIARY DRIVES
MAIN DRIVE
SWING MOTOR
Electric shovels, draglines, and other applications where severe mechanical shock is a factor.
ROTOTROL SELF ENERGIZING FIELD
D.C. GENERATOR
ROTOTROL RESISTOR
D.C. MOTOR
PILOT FIELD
PATTERN FIELD
EXCITER BUS
SPEED ADJUSTING RHEOSTAT
Feed drives for machine tools and other similar requirements. Reversing planers and similar machines.
SUPERCALENDER DRIVE – THREADING SPEED 50 F.P.M. MAXIMUM SPEED 2000 F.P.M.
Elevators – which require accurate landing speeds in either direction.
Paper Supercalenders – which need a low and definite threading speed regardless of friction or loading.
Mine and skiphoists – where a uniform landing or dumping speed regardless of load in hoist is desirable.
ROTOTROL PILOT FIELD (A)
D.C. GENERATOR
D.C. MOTOR
ROTOTROL PILOT FIELD (B)
EXCITATION BUS
MOTOR FIELD
GENERATOR FIELD
ROTOTROL ARMATURE
SPEED CONTROL RHEOSTAT
ROTOTROL SELF ENERGIZING AND PATTERN FIELD
GENERATOR FIELD

Controls Excitation of Power Apparatus



Externally driven auxiliary d.c. generator has several control fields placed on the same pole structure.

Output of auxiliary generator is used to drive other generators or motors, or to govern their operation by controlling the electrical conditions which determine their performance.

Control fields are independently excited by signal devices. The unit responds to and amplifies the resultant action of the signals and translates any departure from the desired performance into a precise correction to restore conditions to those desired.

Multiple control fields are used both to control different functions and to set up a standard of reference to which an indication of ultimate performance is continuously compared.

Each field is easily adjusted or controlled by small resistors or other simple devices.

Rectifiers can be used in the control fields until a specified operating condition or limit is reached.

Signals which indicate changes in operating performance can be obtained from any type of device which measures a condition, translates it into electrical terms, and feeds it back to the control field in a closed-cycle system.

Reference field, generally energized by a constant-voltage source, tends to make the generator deliver maximum output to the apparatus controlled.

Control field or fields oppose the output of the reference field thus producing an excitation of an amount and direction necessary to maintain a desired result.

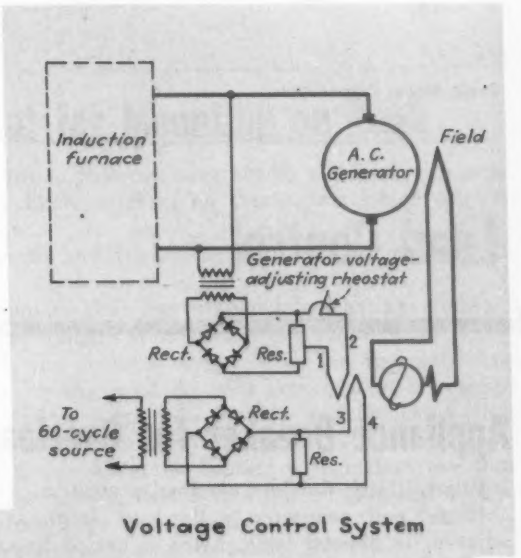
Applications of this control device include:

Matching machine speeds to maintain continuous process control.

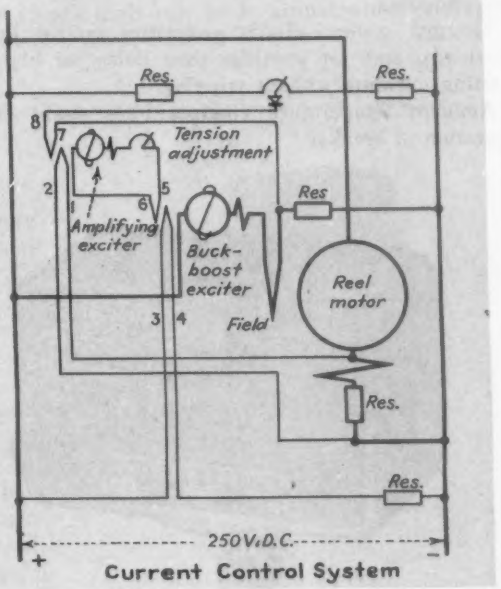
Limiting loads to protect electric systems, to prevent shock loads and destructive stresses in mechanical equipment.

Holding tension to improve uniformity in winding, rolling, and drawing operations.

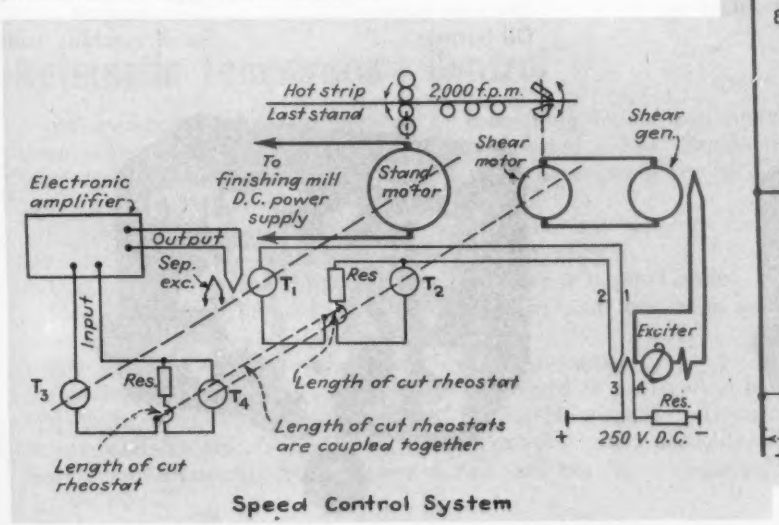
Speeding up acceleration and deceleration to increase production of high inertia machines.



Voltage Control System



Current Control System

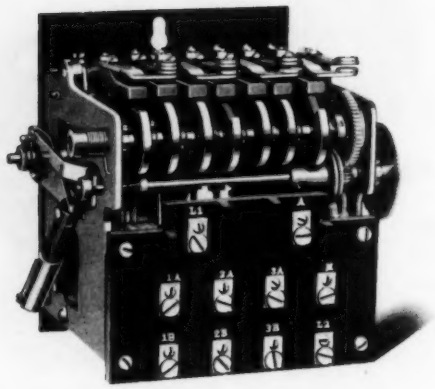


Speed Control System

General Electric Company

Sequence Control

Timer for Automatic Control of Operations



Eagle Signal Corporation

Reset timer, fully automatic, for single cycle multiple circuit applications requiring a time interval between the functioning of two or more contacts.

Low speed synchronous motor drives timer.

Solenoid clutch assembly couples motor to gear train.

Steel clutch has rip saw teeth for positive gripping action.

Shock absorbing device minimizes the jar from the operation of the solenoid.

Each circuit has an "on" and "off" cam and cam follower.

Cams are held on cam shaft with set screws. Cams can be adjusted to close or open circuits at any time within the total time cycle.

Interchangeable gears regulate maximum time cycle from 5 seconds to 5 minutes, or from 10 seconds to 10 minutes.

Contacts are coin silver, ⅜ in. dia., rated for a.c. at 10 amp., 110 volts.

Timer is adjustable to operate with the solenoid normally energized or de-energized.

Load Control

Appliance Breaker for Overload Protection

Bimetal latch provides overload protection.

Heater coil, connected in the load circuit, is mounted adjacent to bimetal latch. Latch is heated by convection and radiation.

Thermal system affords protection against low value overloads, and yet provides time delay on high inrush starting currents without tripping.

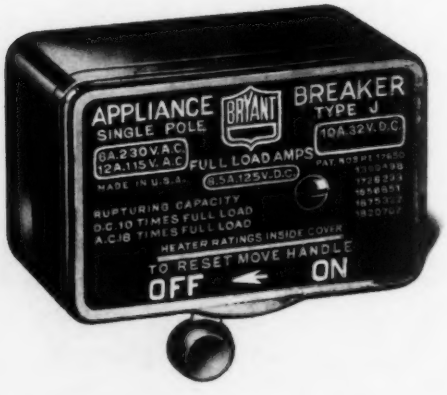
Ambient temperature changes have slight effect on operation of breaker.

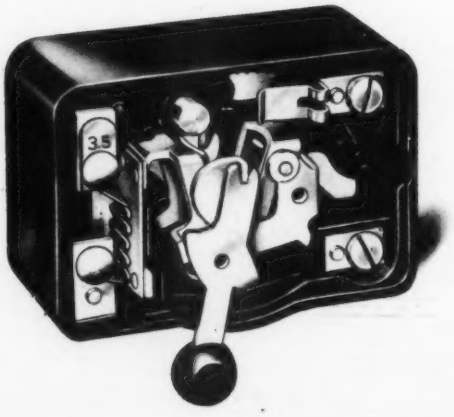
Heater burnout as a result of abnormal current conditions is prevented by fuses installed ahead of the breaker.

Handle of breaker cannot be held in the "On" position should a dangerous overload exist at any time.

Applications Include:

Domestic washing machines	Dishwashers
Domestic ironers	Floor sanders
Oil burners	Small machine tools





Bryant Electric Company

Refrigeration Dual Control

For applications requiring temperature differentials of 2½ deg. F. or more.

Temperature control and high pressure cut-out mechanisms are both mounted in same case.

Indicating scales for both temperature and pressure settings are visible.

Range screw changes both temperature cut-out and cut-in settings.

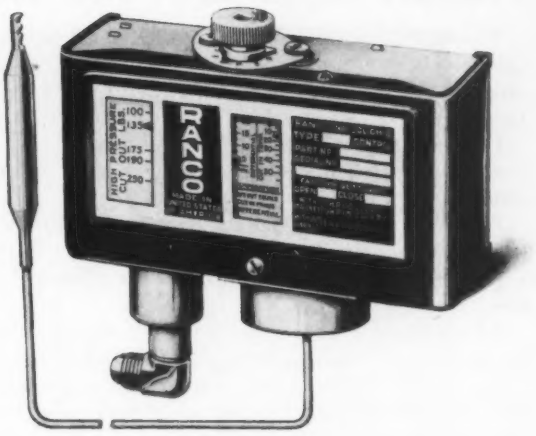
Differential screw changes temperature cut-out point.

Single pole, snap-acting switch closes circuit on increase and opens circuit on decrease in temperature.

High pressure cut-out setting is independently adjustable from 110 to 250 lb. per sq. inch.

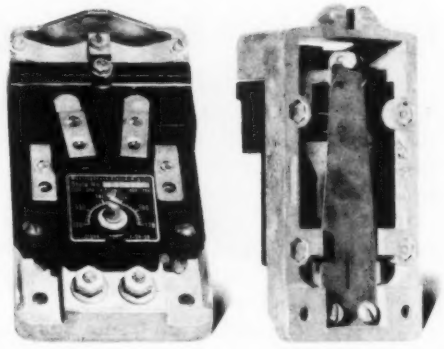
Cut-out mechanism for high pressure actuates the contacts of the temperature control.

Switch opens circuit on pressure rise and recloses circuit when pressure drops 40 lbs. per sq. in. in the high pressure side of controlled system.



Ranco, Inc.

Thermostat for Mounting on Tank



Westinghouse Electric & Manufacturing Company

External mounting prolongs accuracy by eliminating lime deposits that are likely to form on thermostats which are immersed in water.

Preaged bimetal and frictionless springs help maintain accuracy.

Die-cast aluminum alloy base with point mountings arranged for efficient heat transfer from tank to bimetallic strip.

Spring holds the contacts closed while the bi-metal works against another spring until the over center point is reached. Then the thermostat snaps into position and the two springs combine to give maximum contact pressure.

Two spring design maintains contact until instant the bimetal separates the contact, thus decreasing burning and sticking of contacts, and change in calibration.

Maximum rating is 25 amp. or 5 kw., 230 volts.

Adjustable length shaft can be furnished when external adjustment of thermostat is desired.

Automatic Temperature Control

Indicates and regulates temperature by controlling flow of gas, oil or steam when used with motor or solenoid operated valves. Regulates temperature also by controlling electric heating units and relays, or by starting and stopping motors.

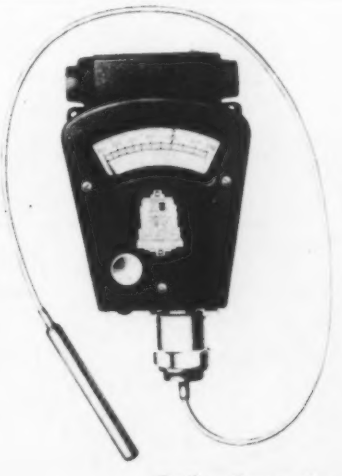
Flexible steel capillary element can be bent into any shape to facilitate placing the bulb in the most advantageous position.

Diaphragm of special construction seals mercury in thermal system.

Sleeve or well is used to protect bulb and adjacent tube when solutions to be controlled would corrode steel.

Knurled knob when turned changes instrument setting.

Contact switch installed in instrument is selected to suit type of control. Capacity of switches are 500 watts, a.c., or 50 watts, d.c. Arrangements available are: Normally on, 2-wire control circuit; normally off, 2-wire control circuit; and three-wire thermostatic control or single pole, double throw.



Partlow Corporation

Pressure Switch and Power Unit

Pressure sensitive bellows in switch unit actuates a spring and solenoid loaded contact armature between two fixed terminals of circuits in series with a high torque proportioning control motor in power unit.

Contact finger is connected electrically to one coil terminal of positioning solenoid the plunger of which is joined to contact armature by a spring.

Potential dividing rheostat, in power unit, is in series with positioning solenoid and control motor.

Rheostat contact arm is keyed to the driving shaft of the power unit.

Decrease in pressure on bellows completes a circuit which causes the power unit to rotate counterclockwise to increase supply, and moves the rheostat arm to increase the voltage to solenoid coil until its pull positions the contact armature between the contacts, thus breaking the motor circuit and stopping the power unit at a new position of supply.

Increase in pressure on bellows moves contact armature to complete a circuit that causes power unit to rotate clockwise, and to reduce voltage on the solenoid coil thus reducing pull of solenoid plunger on contact arm until circuit is broken.

Output shaft of power unit is driven by a shaded pole induction motor through machine cut, heat-treated reduction gears.

Oil submerged units are sealed in a die-cast case.

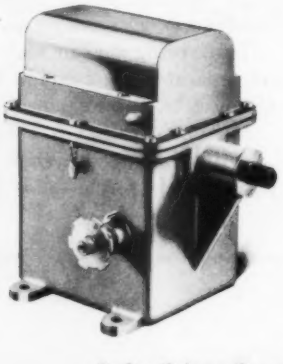
Contacts are protected by a built in condenser.

System operates on 25 volt, 60 cycle, control circuit.

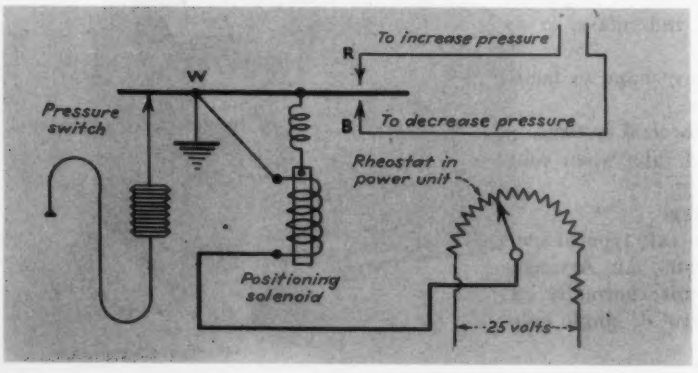
Pressure sensitive bellows and switches are available in range up to 200 lb. per sq. in. pressure.

Case of control motor incloses rheostat to protect it from dirt and dust.

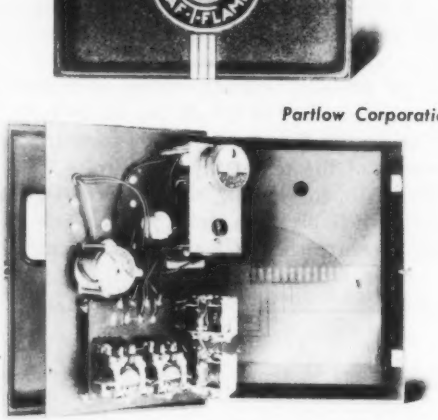
Bellows and switch mechanism is mounted on a plastic material sub-base and inclosed in metal case for surface mounting.



Barber-Colman Company



Partlow Corporation



Flame Failure Breaks Circuit

Operates on electrical conductivity of flame. Not dependent on heat.

Protects any gas or oil-fired appliance that uses a gas pilot from damage which might result from pilot failure.

System consists of relays, an automatic time limit ignitor and relight device mounted in a control cabinet, a transformer and pilot burner with electrodes.

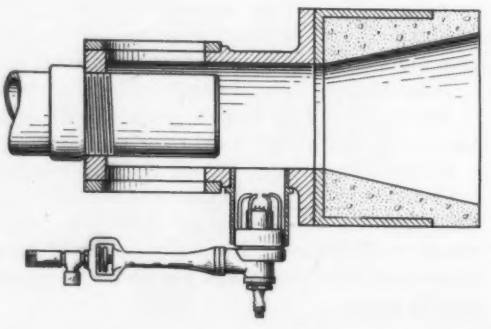
Alloys in electrodes are heat, flame and corrosion resistant.

Flame completes circuit across electrodes to energize a relay that controls electrically operated valves in fuel line.

Relay controlled valves cut off fuel supply when current carrying path is broken by flame failure.

Motor driven interrupter operates magnetic ignition switch intermittently.

Interruptor motor, after ignition, reverses and is stopped at initial starting position by a limit switch.



Small Lightweight Relay

Independent twin contacts on springs provide maximum flexibility in small space, and also keep the power requirements low.

Circuit is completed through one contact even if the other contact is held open by dust or grit.

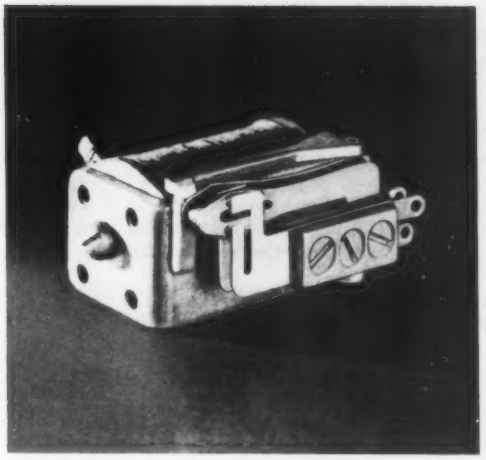
Effective lengths of springs are different in each contacting pair causing the contacts to move through arcs of different lengths, so that contact points wipe over each other and are self-cleaning.

Wear and sticking is reduced by supporting entire length of bronze armature pivot-pin in a brass pillow block.

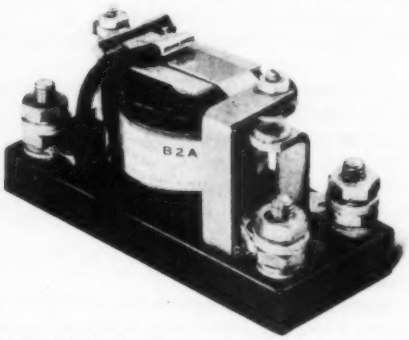
Vibration of moving parts is prevented by keeping the armature backstop and the contact springs under constant torsion while in the normal position.

Operates on d.c., up to 115 volts; will carry up to 100 watts, 2 amp. max. inductive or non-inductive load. Operating time range, 0.004-0.025 sec. Releasing time range, 0.003-0.010 second.

Plug-in mounting types are available with dust protecting covers spun on to seal relay.



Automatic Electric Company



Ward Leonard Electric Company

Low D. C. Voltage Relay

Tail spring tension and contact gap are adjustable for adaptation to the required circuit.

Molded plastic base adds rigidity to the relay assembly and promotes resistance to vibration and shock.

Terminal inserts are anchored and molded in plastic base.

Paper layer wound coils vacuum impregnated for insulation against climatic conditions.

Normally open, single pole, single throw contacts are rated 25 amp. at 24 volts, d.c., non-inductive load.

Acceleration test exceeds 10 gravity and withstands vibrations of 60 cycles and 1/32 in. amplitude.

Lightweight D. C. Relay

Structural box shaped framework, rather than mass, imparts ruggedness and resistance to high acceleration and shock.

Low inertia armature and semi-balanced armature assembly improves resistance to vibration.

Brass bearings, widely spaced, support stainless armature shaft.

Torque of restoring spring on armature is adjusted by varying height of anchor screw.

Positive operation is attained at all vibration frequencies up to 71 cycles with an amplitude of 0.030 in. corresponding to a maximum acceleration of 15 gravity.

Molded phenolic plastic insulating blocks support stationary contacts.

Arc gaps are large to obtain good performance at high altitudes.

Wiping action of contacts dislodges particles of dust and dirt.

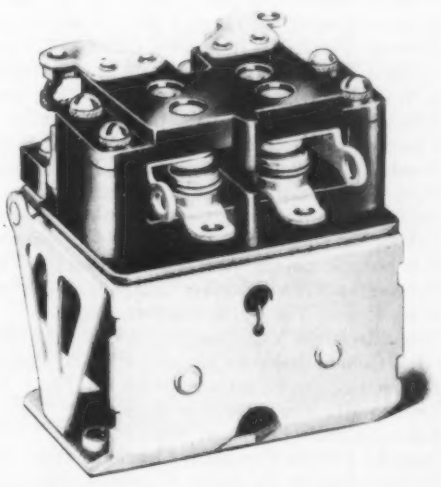
Coils are varnish impregnated and vacuum waxed.

Bipolar core construction permits a large number of coil turns per unit of resistance.

Over-surface leakage paths are made large by use of ribs.

Magnetic material is annealed to obtain optimum properties.

Non-stainless metals are plated to meet the Navy 200 hr., 20 percent salt spray test.



G-M Laboratories, Inc.

Manufacturers of Electric Controls

Acro Electric Company, 1305 Superior Ave., Cleveland, Ohio
Advance Electric Company, Los Angeles, Calif.
Allen Bradley Company, 1329 South 1st St., Milwaukee, Wis.
Allied Control Company, Inc., 2 East End Ave., New York, N. Y.
Allis-Chalmers Mfg. Company, 1126 South 70 St., Milwaukee, Wis.
American Electric Switch Corp., Minerva, Ohio
American Instrument Company, Silver Springs, Md.
Anderson & Company, C. J., 212 West Hubbard St., Chicago, Ill.
Arens Controls, Inc., Chicago, Ill.
Arrow-Hart & Hegeman Electric Company, 103 Hawthorne St., Hartford, Conn.
Automatic Electric Company, 1033 West Van Buren St., Chicago, Ill.
Automatic Reclosing Circuit Breaker Company, Columbus, Ohio
Automatic Temperature Control Company, Inc., 34 East Logan St., Phila., Pa.
Barber-Colman Company, Rockford, Ill.
Benwood-Linze Company, St. Louis, Mo.
B-L Electric Mfg. Company, St. Louis, Mo.
Bridgeport Switch Company, Bridgeport, Conn.
Bristol Company, Waterbury, Conn.
Brown Instrument Company, 4535 Wayne Ave., Philadelphia, Penn.
Bryant Electric Company, Bridgeport, Conn.
Callite-Tungsten Corp., 540 39 St., Union City, N. J.
Cinaudograph Company, Stamford, Conn.
Clare & Company, C. P., 4719 Sunnyside Ave., Chicago, Ill.
Clark Controller Company, 1146 East 152 St., Cleveland, Ohio
Cole-Hersee Company, 54 Old Colony Ave., Boston, Mass.
Colt's Patent Fire Arms Mfg. Company, 17 Van Dyke Ave., Hartford, Conn.
Continental Electric Company, 325 Ferry St., Geneva, Ill.
Cramer Company, R. W., Centerbrook, Conn.
Crouse-Hinds Company, Syracuse. N. Y.
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee, Wis.
Durakool, Inc., 1031 North Main St., Elkhardt, Ind.
Eagle Electric Mfg. Company, Brooklyn, N. Y.
Eagle Signal Corp., Moline, Ill.
Edison, Inc., Thomas A., West Orange, N. J.
Edwards and Company, Norwalk, Conn.
Electric Controls Corp., New York, N. Y.
Electric Controller & Mfg. Company, Cleveland, Ohio
Electron Equipment Co., Palm Springs, Calif.
Englehard, Inc., Charles, Newark, N. J.
Euclid Electric & Mfg. Company, Euclid, Ohio
Fairbanks, Morse & Company, 600 South Michigan Ave., Chicago, Ill.
Friez and Sons, Inc., Julian P., Baltimore, Md.
Furnas Electric Company, Batavia, Ill.
Gamewell Company, Newton Upper Falls, Mass.
Gem Engineering Corp., Hempstead, N. Y.
General Control Company, 243 Broadway, Cambridge, Mass.
General Electric Company, 1 River Road, Schenectady, N. Y.
General Electronics Industries, Greenwich, Conn.
General Radio Company, 30 State St., Cambridge, Mass.
G-M Laboratories, Inc., 4300 N. Knox Ave., Chicago, Ill.
Gregory Mfg. Company, Mt. Carmel, Conn.
Guardian Electric Mfg. Company, 1600 W. Walnut St., Chicago, Ill.
Hardwick-Hindle, Inc., Newark, N. J.
Hart Manufacturing Company, Hartford, Conn.
Haskins Manufacturing Company, Detroit, Mich.
Haydon Manufacturing Company, Inc., Forestville, Conn.
H-B Electric Company, 6122 North 21st St., Philadelphia, Pa.
Heinemann Circuit Breaker Company, 610 Plum St., Trenton, N. J.
Hubbell, Inc., Harvey, Bridgeport, Conn.
Ideal Electric & Mfg. Company, Mansfield, Ohio
I-T-E Circuit Breaker Company, Philadelphia, Pa.
Jefferson Electric Company, Bellwood, Ill.
Kel-San Mfg. Company, Dayton, Ohio
Kolton Electric Company, Newark, N. J.
Laganke Electric Company, Cleveland, Ohio
Leonard Electric Company, Cleveland, Ohio
Lexington Electrical Products Company, Newark, N. J.
Mallory Company, P. R., Indianapolis, Ind.
Marsh Tritrol Company, 600 S. Michigan Ave., Chicago, Ill.
McCorkle Company, D. H., Berkeley, Calif.
Mercoid Company, 4201 Belmont St., Chicago, Ill.
Metropolitan Electric Mfg. Company, Long Island City. N. Y.
Micro Switch Corporation, Freeport, Ill.
Minneapolis-Honeywell Regulator Company, Minneapolis, Minn.
Monitor Controller Company, Baltimore, Md.
Mossman, Inc., Donald P., 6133 N. Northwest Highway, Chicago, Ill.
Mu-Switch Corp., Canton, Mass.
National Electric Controller Company, Chicago, Ill.
New Haven Clock Company, New Haven, Conn.
Northwestern Clock Company, Omaha, Neb.
Ohmite Mfg. Company, 4835 West Flournoy St., Chicago, Ill.
Paragon Electric Company, 37 West Van Buren St., Chicago, Ill.
Partlow Corp., 2 Campion Road, New Hartford, N. Y.
Pass and Seymour, Inc., Solvay Station, Syrcasue, N. Y.
Penn Electrical Company, Irwin, Pa.
Penn Electric Switch Company, Goshen, Ind.
Perfex Controls Company, Milwaukee, Wis.
Plainville Electrical Products Co., Plainville, Conn.
Powrex Switch Company, Waltham, Mass.
Production Instrument Company, Chicago, Ill.
Ranco Inc., 601 West 5th Ave., Columbus, Ohio
Rawson Electrical Instrument Company, Cambridge, Mass.
R B M Mfg. Company, Logansport, Ind.
Redmond Company; A. G., Owasso, Mich.
Reliance Automatic Lighting Company, Racine, Wis.
Reliance Electric & Engrg. Company, 1088 Ivanhoe Rd., Cleveland, Ohio
Reynolds Electric Company, 2650 W. Congress St., Chicago, Ill.
Rhodes, Inc., M. H., Hartford, Conn.
Rochester Mfg. Company, Rochester, N. Y.
Roller-Smith Company, Bethlehem, Pa.
Rowan Controller Company, Baltimore, Md.
Russell Electric Company. 340 W. Huron St., Chicago, Ill.
Sangamo Electric Company, Springfield, Ill.
Signal Electric & Mfg. Company, 154 West 14 St., New York, N. Y.
Smith, Inc., Winfield H., Springville, N. Y.
South Bend Current Controller Company, South Bend, Ind.
Spencer Thermostat Company, 34 Forrest T., Attleboro, Mass.
Square D Company, 4041 N. Richards St., Milwaukee, Wis.
Stromberg Electric Company, Chicago, Ill.
Stromberg Time Corp., 109 Lafayette St., New York, N. Y.
Struthers Dunn, Inc., Philadelphia, Pa.
Sundh Electric Company, Cleveland, Ohio
Supreme Electric Products Corp., Rochester, N. Y.
Tagliabue Mfg. Company, C. J., Brooklyn, N. Y.
Taylor Instrument Company, Rochester, N. Y.
Thompson Inc., Long Island City. N. Y.
Thompson Clock Company, H. C., Bristol, Conn.
Titan Valve & Mfg. Company, 9913 Elk Ave., Cleveland, Ohio
Tork Clock Company, Mt. Vernon, N. Y.
Trombetta Solenoid Company, Milwaukee, Wis.
Trumbull Electric Mfg. Company, Plainville, Conn.
Udylite Company, 1651 East Grand Blvd., Detroit, Mich.
United Cinephone Corp., Torrington, Conn.
Walzer Automatic Timer Company, New York, N. Y.
Ward-Leonard Electric Company, 31 South St., Mt. Vernon, N. Y.
Warren Electric Appliance Company, Warren, Pa.
Warren Telechron Company, Ashland, Mass.
Westinghouse Electric & Mfg. Company, East Pittsburgh, Penn.
Weston Electrical Instrument Compnay, 614 Frelinghuysen Ave., Newark, N. J.
Wheelco Instruments Company, Harrison and Peoria Sts., Chicago, Ill.
Wiegand Company, Edwin L., 7500 Thomas Blvd., Pittsburgh, Pa.
Zenith Electric Company, 152 West Walton St., Chicago, Ill.

Simplified Procedure Devised For Scaling Perspective Drawings

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Fleetwings Division, Kaiser Cargo, Inc.

New technique embraces standard methods of formal perspective but eliminates points considered non-essential. Basic principles of the system are presented.

FORMAL perspective drawing used to be regarded as a laborious, complicated process, too slow for general use in the industrial field, too difficult to be taught generally. As a result, substitute methods of pictorial presentation were devised, such as geometric perspective projection, isometric, cabinet oblique, and other less popular forms of axonometric and oblique projection.

In the opinion of the authors, the only satisfactory method of making scaled pictorial drawings of technical subjects is scaled perspective. Geometric, axonometric and oblique projection—all substitute methods—give, at best, distorted views which fail to satisfy the eye and leave the mind in doubt as to the true shape and character of the object depicted.

Because of the need for developing a standard method and because a number of inexperienced persons had to be taught in a hurry, it was necessary to devise a method which was at once sound, simple to teach and easy to understand. The results described herewith represent a simplified method of scaled perspective based upon standard methods of formal perspective, but eliminating all non-essentials.

The structure of the system is primarily that of vertical and horizontal planes, intersecting at 90 deg., as shown in Fig. 1(*A*). The vertical interestction, called station *O* vertical, is assumed to be on the picture plane. Only that portion of the basic structure and extensions thereof which lie behind the picture plane, Fig. 1(*B*), can be used for plotting the object to be drawn.

Definition of Terms

The following terms are defined according to their practical application in the simplified method:

Picture Plane—The surface of the paper on which the drawing is made. This surface should be considered as a pane of glass behind which the object rests. Any attempt to extend the drawing of the object forward of this theoretical pane of glass, or in front of the paper surface, is unpractical.

Vertical Cutting Planes (Primary)—Vertical planes intersecting at 90 deg. at the picture plane. They represent the visible vertical planes of the object, or of the imaginary rectangle that incloses the object, and are parallel to its intersecting center lines. They are also called perspective planes.

Base Line (Measuring)—The line of intersection with the picture plane of the basic horizontal plane upon which the object rests. It is the primary horizontal measuring line.

Perspective Base Lines—Represent the intersections, in perspective, of the vertical cutting planes with the basic horizontal plane.

Horizon Line—The eye-level line. It contains the vanishing points of all horizontal lines.

Vanishing Points (Normal)—Points, located by the intersections of the perspective base lines with the horizon, to which all lines parallel to the horizontal center lines of the object converge.

Vanishing Points (Accidental)—Vanishing points for lines parallel to neither the vertical nor the horizontal center lines of the object. (See Axioms 3 and 4 following).

Station *O* Vertical—Line formed by the intersection of the cutting planes at the picture plane. It is the primary vertical measuring line.

Station Point—The point on the station *O* vertical where an angle of 90 deg. is formed by the intersection of lines drawn to the vanishing points. It is located at the point where the vertical intersects a circle the diameter of which is the distance between vanishing points on the horizon.

Measuring Points—Points on the horizon used in projecting points from the picture plane to the perspective planes. They are located by drawing

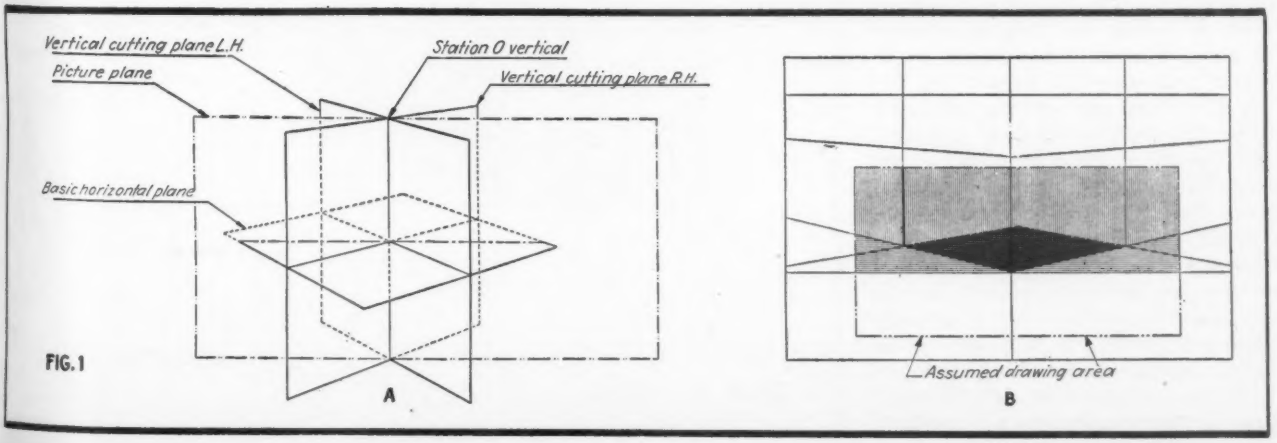


FIG. 1

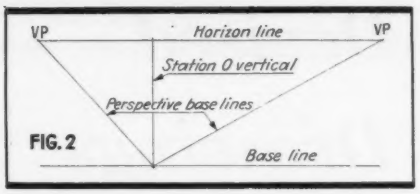


FIG. 2

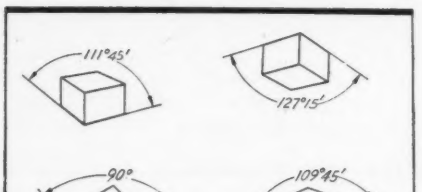


FIG. 3

arcs, using the vanishing points as centers, from the station point and intersecting the horizon. The intersection of this arc and the horizon is the measuring point.

The following developments of basic geometric axioms apply to sound perspective drawing:

1. A point projected becomes a line. A line projected becomes a plane. A plane projected becomes a solid.

2. All parallel lines in perspective have a common vanishing point.

3. All horizontal lines, except those parallel to the picture plane, have their vanishing points in the horizon.

4. All lines that are neither vertical nor horizontal have their vanishing points in vertical lines passing through the vanishing points of horizontal lines lying in their vertical planes.

5. A circle in perspective becomes an asymmetrical ellipse, the long axis of which is always at 90 deg. to the longitudinal center line of the cylinder formed by projection of the circle.

6. Angle between the perspective base lines must not be less than 105 deg.

7. The station point lies always in the circumference of a circle the diameter of which is the distance between vanishing points on the horizon. It occurs above or below the horizon, depending upon whether the object is to be viewed from above or below.

8. The distances between vanishing points and between horizon and base line depend on the size of the object to be drawn and the view to be shown. These distances must be great enough to avoid distortion.

To make scaled perspective drawings by the simplified system, lay out the perspective base lines at a suitable angle for the view to be shown, as in Fig. 2. At the point where they intersect draw the base line. At the same point of intersection erect a vertical. This is the station *O* vertical. Draw the horizon line at a height above the base line which will allow sufficient distance between the points of its intersection with the perspective base lines. These are the vanishing points.

The station *O* vertical (vertical measuring line) and the base line (horizontal measuring line) are on the picture plane. The perspective base lines recede to the horizon and represent, in perspective, the horizontal lower edges of planes intersecting at 90 deg. at the picture plane. This angle would be seen at its true 90 deg. only if it were viewed directly from above. In perspective, the angle widens with the flattening of the plane until, at eye level, it reaches 180 deg. In order to avoid distortion it is recommended that an angle of not less than 105 deg. be used to represent the true 90 deg., Fig. 3. An angle of less than 105 deg. would necessitate the use of three-point perspective to avoid distortion.

All scaling is done on the base line and on the vertical measuring line, or on secondary vertical and horizontal measuring lines established for convenience. Dimensions are normal on the picture plane. From the station *O* vertical, which generally represents the nearest corner of the piece or the imaginary rectangle which incloses the piece where it touches the picture plane, dimensions can be projected directly into the perspective planes by aligning the points of measurement with either of the two normal vanishing points.

To project dimensions from the horizontal measuring line to the perspective planes, measuring points are needed. These are located quickly as shown in Fig. 4(*A*), by drawing a semicircle, the diameter of which represents the distance between vanishing points in reduced scale, and erecting a vertical in the same relative position as in the large layout. This vertical should intersect the semicircle.

The area of true vision, which is the limited portion of the complete field of vision in which objects appear in sharp focus, is generally accepted as falling within a 60-deg. cone, Fig. 4(*B*). As a further safeguard against distortion it is advisable to keep the drawing area within this cone. From the station point draw lines 30 deg. on either side of the station *O* vertical until they intersect the horizon line.

Theoretically, a semi-circle, the center of which lies at station *O* vertical on the horizon line and the diameter of which is the distance between 30-deg. lines at their intersection with the horizon line, should now be drawn. However, because the horizontal range of vision is much greater than the vertical range, the true cone of accurate vision is not circular, but elliptical, with the long axis horizontal. It is,

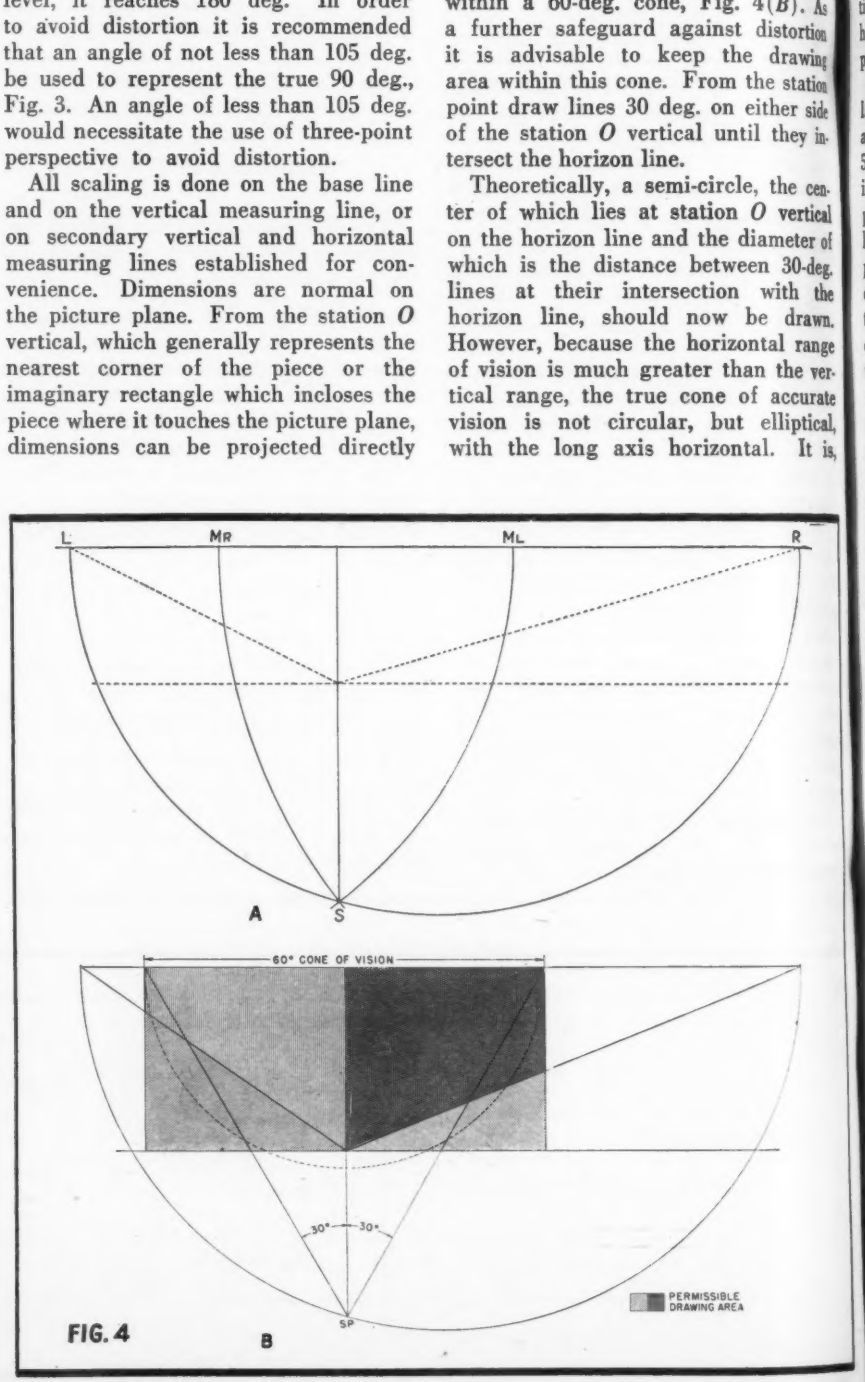


FIG. 4

therefore, permissible to drop verticals from these intersections to the horizontal base line to find the limits of the drawing area within which distortion can be avoided.

With L as the left-hand vanishing point, Fig. 4(A), R as the right-hand vanishing point, and S as the point of intersection of the verticals and the semi-circle (the station point), use L as a center and LS as a radius and then intersect LR to find the measuring point for horizontal dimensions on the left-hand perspective plane. With R as center and RS as radius, intersect LR to find the measuring point for horizontal dimensions on the right-hand perspective plane. Locate these points on the horizon of the large layout by simple proportion.

Given a piece as shown in Fig. 5(A), lay out dimensions on the base line and station O vertical as shown in Fig. 5(B). Project the dimensions as shown in Fig. 5(C). The points where lines projected from dimensions on the horizontal measuring line intersect the perspective base lines represent those dimensions in perspective. At each of these points erect a vertical the height of which is determined by its intersection with a line projected toward the vanishing point from a dimension point on the vertical measuring line. This procedure, illustrated by Fig. 5(D), establishes in perspective the dimensions of the primary vertical faces.

To establish the horizontal planes of the object, project lines from the corners of the right and left vertical planes toward the opposite vanishing points, Fig. 5(E), until they intersect.

By this procedure a point can be accurately located anywhere within the space limits of the perspective system. Fig. 5(F) shows the piece illustrated in Fig. 5(A) drawn in scaled perspective.

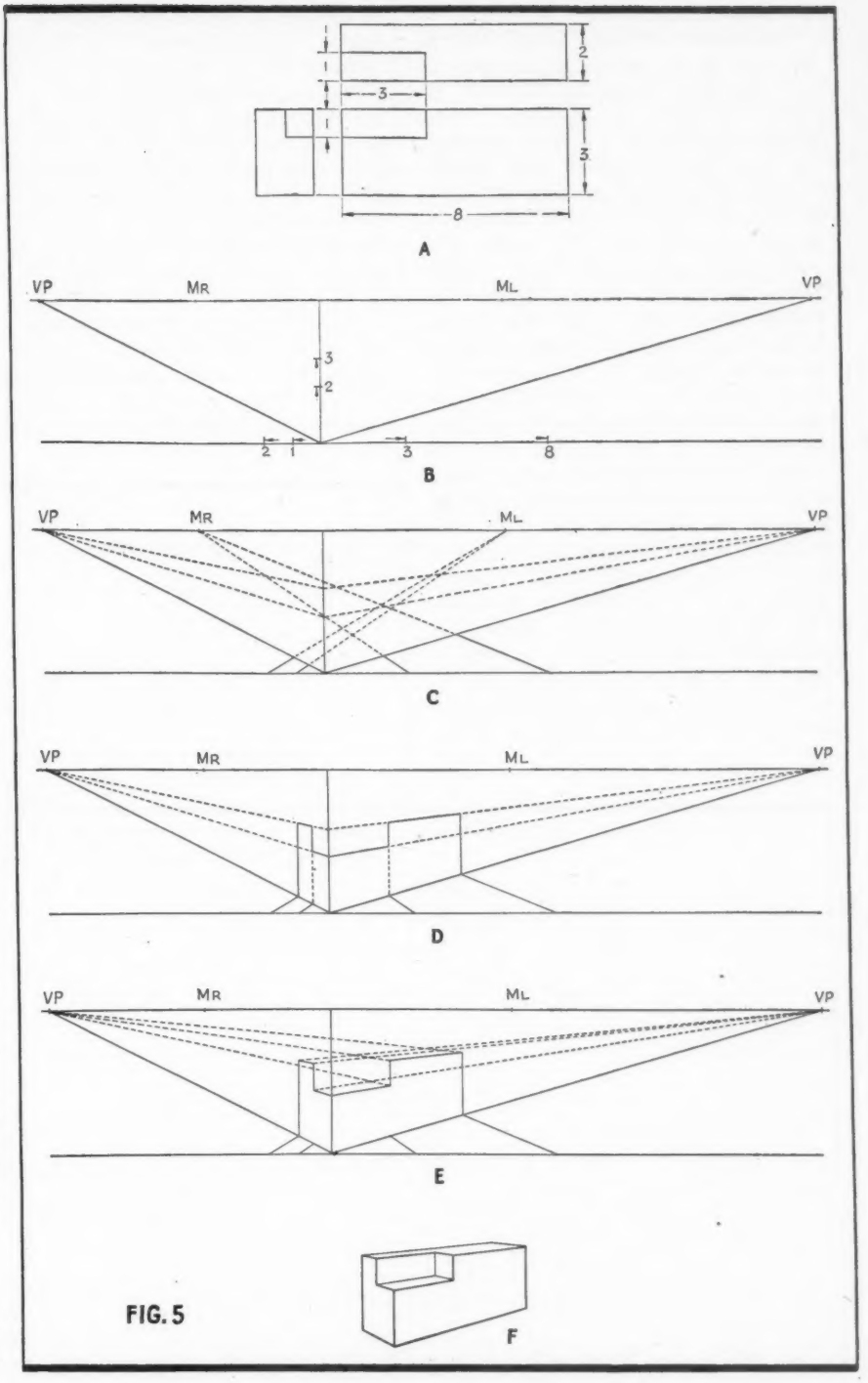


FIG. 5

Circles in Perspective

Given the location of the circle, by laying out the center and diameter on the station O vertical at the proper height above the base line and on the base line at the proper distance to the right or left of the station O vertical, Fig. 6. Project the points on the base line to the perspective plane and erect verticals. Project lines from the points on the vertical measuring line toward the vanishing point until they intersect the verticals. Within the square with intersecting center lines thus formed in perspective, draw an ellipse tangent to the square at the four points where the center lines intersect its sides. The direction of the side of the square estab-

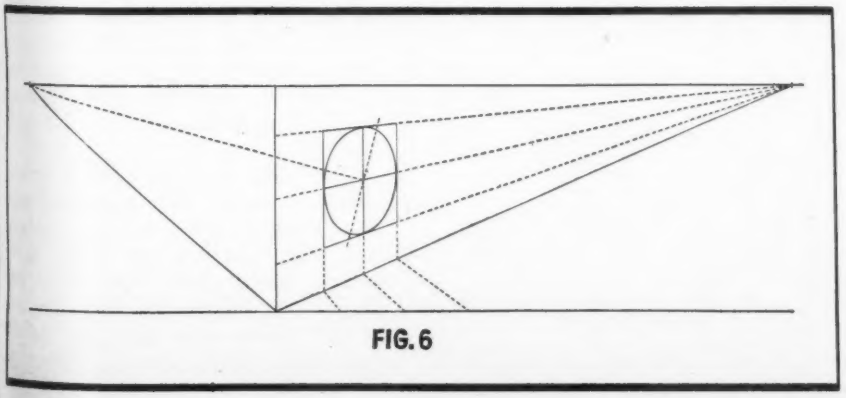


FIG. 6

lishes the direction of the curve at the point of tangency.

Additional reference points can be obtained by use of the intersections of the diagonals of the square with the circle, as shown in Fig. 7(*A*). The figure is shown here orthographically, on both the horizontal and vertical measuring lines, for purposes of clarity. Only one such view is necessary in actual practice. In Fig. 7(*B*) the projections are made from single orthographic views. To the right of the station *O* vertical is shown the method of projecting a circle using the eight points established by the intersections of the center lines with the sides of the square (points of tangency) and the intersections of the diagonals with the circle. These points are carried vertically to the horizontal measuring line, making five points on that line, projected to the perspective base line and thence again vertically. The diameter of the circle is measured on the vertical measuring line and projected to the vanishing point. Thus, a square is again set up in perspective, with its vertical center line and two additional vertical lines. Draw the diagonal of the square. Where it intersects the vertical center line is located the center of the square; where it intersects the other two verticals are two points of intersection of the diagonal and circle. Lines passing through each of these points and going to the vanishing point will locate the center points on the vertical sides of the square and the intersections of the other diagonal with the circle. Plot the circle in perspective as in Fig. 7(*C*), right, so that it passes through all of the eight points.

At the left of the vertical measuring line in Fig.7(*C*) is shown a method using twelve points established by means of 30-deg. and 60-deg. angles intersecting the circle. By similar means any number of points can be used for greater accuracy. Extreme accuracy is essential in the establishment and projection of points, no matter how many are used. An almost unnoticeable error in locating or projecting a point can cause a glaring deviation in a curve. In general practice, eight points are sufficient for plotting a circle, and for a trained eye four points will often suffice.

Horizontal circles are drawn by similar methods, except that the dimensions are laid out on, and projected from, the base line at the proper locations, as shown in Fig. 8, on either side of the station *O* vertical.

Irregular curves are plotted in perspective, as in orthographic drawing, by means of ordinates at dimensioned intervals through a center or reference line. The curve can be plotted orthographically on the picture plane and projected by use of the ordinates to the perspective planes, or the ordinate dimensions can be laid out on the measuring lines, projected to the perspective planes and the curve plotted directly in perspective as shown in Fig. 9. The latter method is quicker and just as accurate as the first.

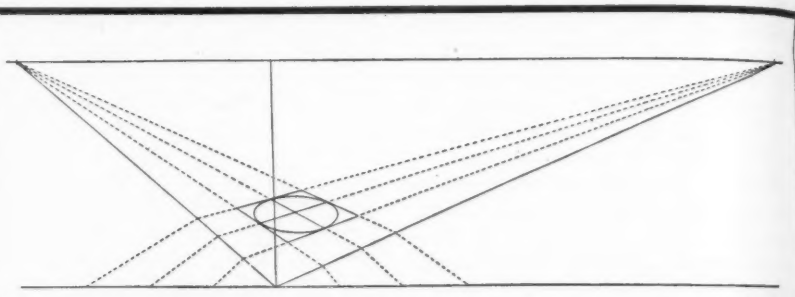


FIG. 8

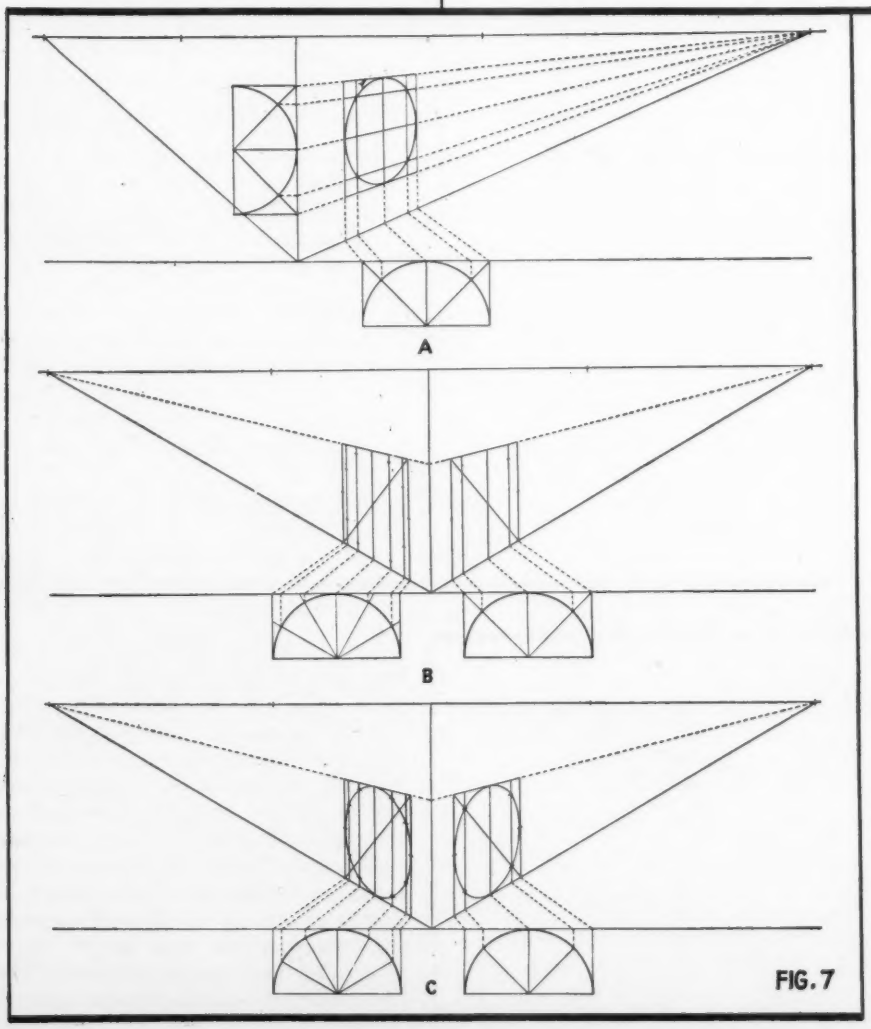


FIG. 7

Angles and Oblique Lines

In orthographic drawing an oblique line can be stated in terms of its angle to a reference line, Fig. 10(*A*) or Fig. 10(*B*), in terms of the distance of each end from a reference line. It can also be projected in two ways: Vertically, as shown in Fig. 11(*A*), from an orthographic view on the picture plane, and Fig. 11(*B*), from dimensions laid out on the horizontal and vertical measuring lines.

There are also two ways to project oblique lines in their horizontal position. From the lower end of the oblique line, Fig. 12(*A*), project a line to the cutting plane. From the upper end drop a vertical to the base line and project a line from that point to the right-hand cutting plane and thence to the left-hand vanishing points. Project

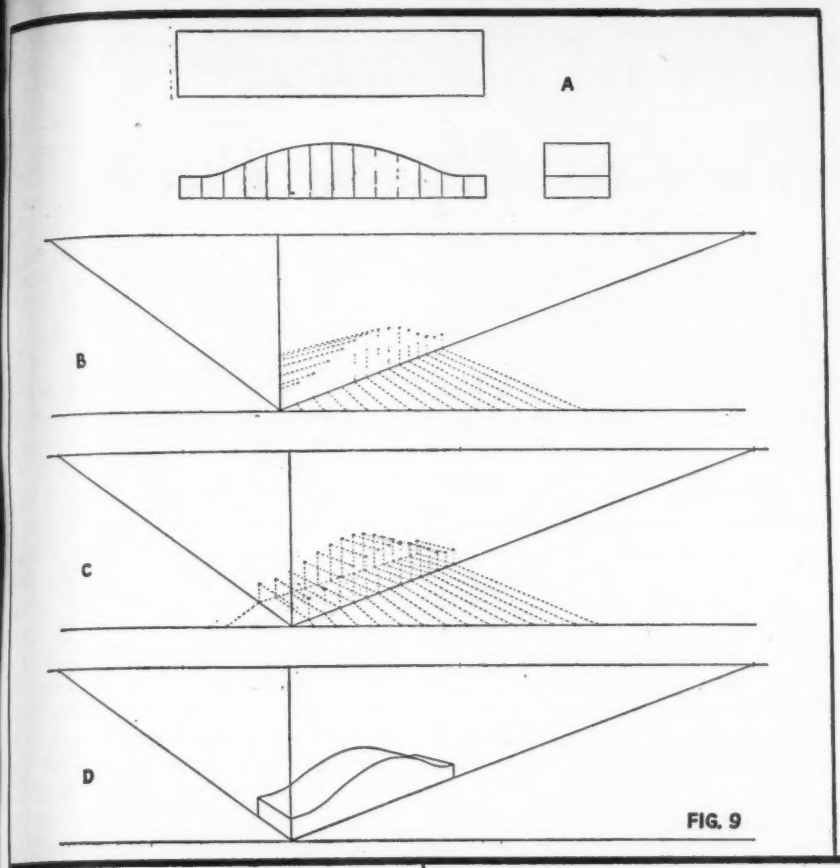


FIG. 9

From the orthographic views shown in Fig. 13(*A*), lay out the dimensions, as shown in Fig. 13(*b*), on the horizontal and vertical measuring lines and project.

To locate the vanishing point of an oblique line draw a horizontal line lying in its vertical plane (represented by the short leg of the triangle which lies, of course, in the same vertical plane as the hypotenuse, and which rests on the basic horizontal plane) and continue it to the horizon. At the point of its interestction with the horizon, erect a vertical. Continue the oblique line until it intersects the vertical. That intersection is the vanishing point for all lines parallel to the oblique line.

With an understanding of the basic principles given here, the system can be adapted—by logical application—to an accurate statement of any form, or complicated arrangement of forms, in any position. Experience has shown that most draftsmen and artists can learn to make accurate scaled perspective illustrations in an amazingly short period of time after a thorough study of this method and with a minimum of practice.

a horizontal line from the upper end of the oblique line to the vertical measuring line. From that point describe an arc to the base line and project from that point to the left-hand cutting plane, thence to the right-hand vanishing point. The intersection of the two lines to the vanishing points establishes the far end of the oblique line, lying on the horizontal plane. Fig. 12(*B*) illustrates the method of projecting from dimensions laid out on the horizontal measuring line.

A line not parallel to the horizontal plane or to either cutting plane can be projected as in Fig. 13. For purposes of clarification, a triangle, the hypoteneuse of which represents the oblique lines to be plotted, is shown.

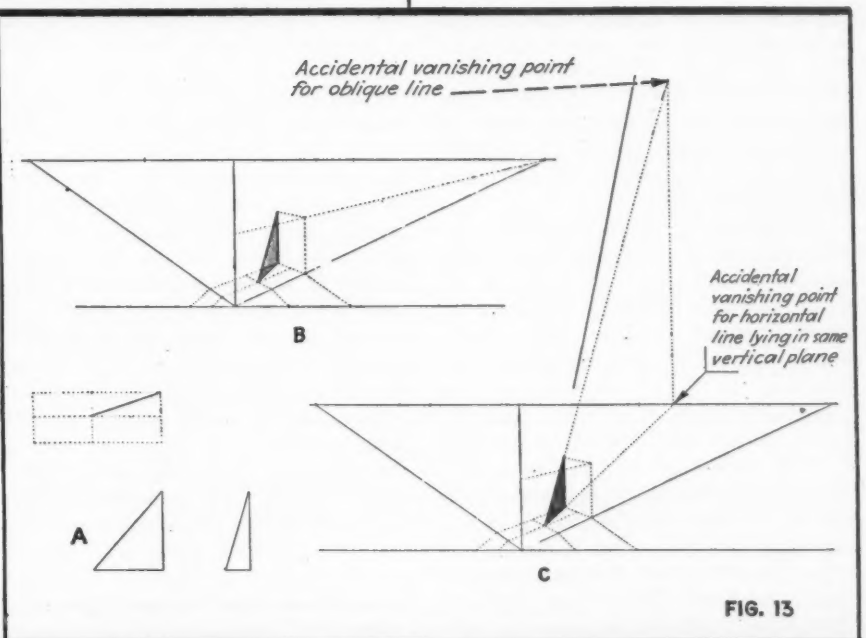
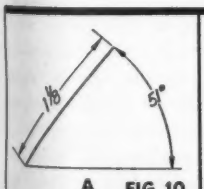
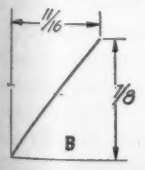

Accidental vanishing point for oblique line
Accidental vanishing point for horizontal line lying in same vertical plane
A
B
C

FIG. 13



A FIG. 10



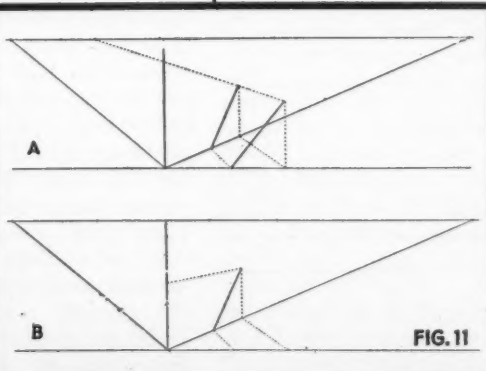


FIG. 11

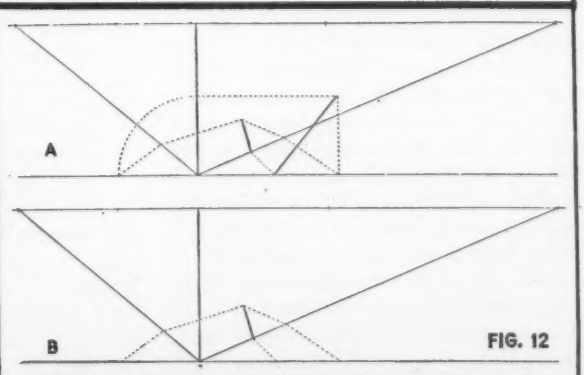


FIG. 12

Knowledge of Shrinkage Aids in Design of Plastic Parts

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Proper procedures in designing molds and locating inserts to allow for shrinkage are stressed. The principles apply to use of phenolic and other types of plastics.

DESIGNING with molded phenolics requires a thorough knowledge of the shrinkage properties of the materials under consideration to insure success of the finished part. The difference in length between the molded piece and cold mold, expressed in inches per inch of length, is the shrinkage. This contraction keeps inserts tightly imbedded and aids in ejection of the part from the mold, but in some instances causes a part to crack when it is improperly designed.

The transfer method—one of the latest advances in molding—has opened new possibilities for closer tolerances than ever before. This and other progressive steps have made practicable more complicated shapes, the use of more and/or larger inserts, easier molding of side and angular holes and intricate threaded holes.

Allowances for shrinkage are the secrets behind better mold design. The amount of shrinkage that occurs in intricate shapes is difficult to predict from simple measurement. Generally speaking, the larger the piece, the greater the problem.

Ordinary limits of accuracy for 1- to 3-in. sections are ±0.004 to ±0.010 in. The limits for larger pieces will vary proportionately. Design should allow for further slight shrinkage or expansion which may occur if the part is exposed to extremely dry or extremely moist conditions over long periods. Tables are available that give the different values for shrinkage and expansion under such conditions.

One method for determining shrinkage during molding is to use a flash-type hand mold for molding a channel-shaped piece measuring approximately 6x1x¼ in. This mold is accurately calibrated in length to 0.001 in. at 700 deg. F. The mold is heated to 300 deg. F., then loaded with the material to be tested and a cured molded test specimen produced at a pressure of 4,500 lb. per sq. inch. After the molded specimen reaches room temperature its length is accurately measured in thousandths of an inch and the result deducted from the length of the cold mold. The difference is then divided by the inside length of the mold, giving the shrinkage factor of the molded specimen in inches per inch of length. Another method for determining shrinkage is to mold ½x½x5 in. test bars under the same conditions and measure them similarly.

Shrinkage depends to a large extent on the state of cure and nature of the piece. It varies with the plasticity of the material, and is caused by a combination of effects. First, the thermal contraction of plastics is different from that of the steel in which they are molded, as indicated in Table I. Second, contraction is caused by the polymerization which takes place in the material during the cure. Actually, the specific gravity increases slightly. Third, the modulus of elasticity affects shrinkage. However, it has a negative effect and has much less effect ordinarily than the first two points mentioned. Since the molded piece is compressed during molding, it expands slightly when the pressure is released. Shrinkage may also be affected by poorly designed split-type or sectional molds which expand slightly under pressure.

From Table II it might be assumed that by simply using a material which has low shrinkage all problems of cracking would be solved. In practice such is not the case because the modulus of elasticity must be considered. For instance, the mineral-filled phenolics have low shrinkage, which is to be expected. The modulus of elasticity for mineral-filled materials, however, is considerably higher than that for general-purpose types. Furthermore, as a general rule the ultimate tensile strength of the mineral-filled material is no greater than that of the general-purpose material. Mineral-filled materials, consequently, will be found to crack just as readily as general-purpose compounds.

Some of these difficulties are overcome by special compounding of materials. Certain types of materials must be used to impart required physical properties to the finished molded part. Some applications require specific types of material. For instance, if a part must have a low power factor, only a low power factor material can be used. The same holds true if the application requires a high dielectric strength material; only that type can be used. There are, of course, many physical properties common to all phenolics but almost any one of these properties can be intensified, even to the point where the material serves for only one specific application.

Another point which the mold designer must consider is the change in length due to fin thickness. For example, in a cup-shaped piece which is to be 6x1¼ in. the base thickness is ¼ in., which leaves 1 in. for the inside dimension of the 1⅛-in. thick side wall. The shrinkage allowance in the mold dimensions must be made for the over-all width of 6 in. and the inside width of 5¾ in. In a piece of this length no shrinkage should be allowed for in the over-all height because the height increases due to fin thickness. This is accounted for by an assumed fin or flash of 0.010 in. which is always present in the average compression mold. Assuming the phenolic material selected has a shrinkage of 0.008 in. per in., the mold dimensions for the height should be 1.250 in.

Table I—Thermal Expansion

Coefficient of linear expansion x 10^{-6} per deg. C., 30-60 deg. C.

TYPE PHENOLIC	
General Purpose	41–44
Impact	22–43
Non-Bleed	40–47
Electrical	19–23
Heat Resistant	24–34
Special Purpose	49
TYPE METAL	
Aluminum	24
Brass	19
Copper	9
Steel	12

to deliver the desired height of 1.25 in. However, the male section will still be 1.008 in. to deliver the desired inside wall depth of 1 in. Naturally, on pieces of greater over-all height the effect of the flash diminishes. If the above piece were to be 6 in. high instead of 1¼ in., this mold dimension would be 6.038 in. Original figures would show that a shrinkage of 0.048 in. should be allowed. The allowance becomes 0.038 in. when the same 0.010-in. flash is assumed.

Large pieces may be distorted at usual molding temperatures because of uneven cooling, improper placement and spacing of ejector pins or improper handling. The most common practice, and a "must" where especially close tolerance is required in a large piece, is to use a fixture to hold the piece while it is cooling. Another point to check is the air circulation around the cooling piece. Directly related to this is the atmospheric condition of the room. Ejector pins should never be placed at a thin section of the piece. If the piece is of ribbed construction, the ejector pins should be placed close to the ribs. Improper handling of pieces on removal from the mold is a matter of common sense. It is poor practice, for example, to pile large pieces on top of each other, or in a hit-or-miss fashion in a container, while they are still hot.

In transfer molding shrinkage may drop to as low as 25 percent of the normal value. This is probably caused by higher pressures and the fact that the material has partly cured by the time it fills the mold. Experience is the best teacher in determining how much less shrinkage there is in transfer molding compared with compression molding.

Large stresses are created around inserts during cooling because of the difference in shrinkage of the materials. Stress required to hold inserts tightly is partially relieved during the first stage of cooling by the slight amount of "flow" still remaining in the plastic. Nearly all phenolic compounds have a minimum of this "flow." However, because of the differences between the shrinkage of the phenolic material and the thermal contraction of the metal, any variation in size of inserts must be taken into account. In some pieces having large, intricate inserts it is necessary to use a phenolic that will retain some of this "flow" until the part has cooled almost to room temperature. This type of material does not have the usual rigidity at molding temperature and presents other molding difficulties. Naturally, it is not recommended except where it is vitally essential to manufacture of the part.

Correct design for inserts is of prime importance in molding. One of the difficult problems encountered is shown in Fig. 1. Frequently, in transfer molding, the material fibers are oriented and cause weak points, which have the same effect as improperly designed inserts. Cracking may be the result of the heat generated during transfer of the material through the orifices or gates. The material is heated too rapidly and begins to set before it has welded together thoroughly. This causes weak spots and shows cracks at the weld marks. These cracks, however, are not caused primarily by shrinkage.

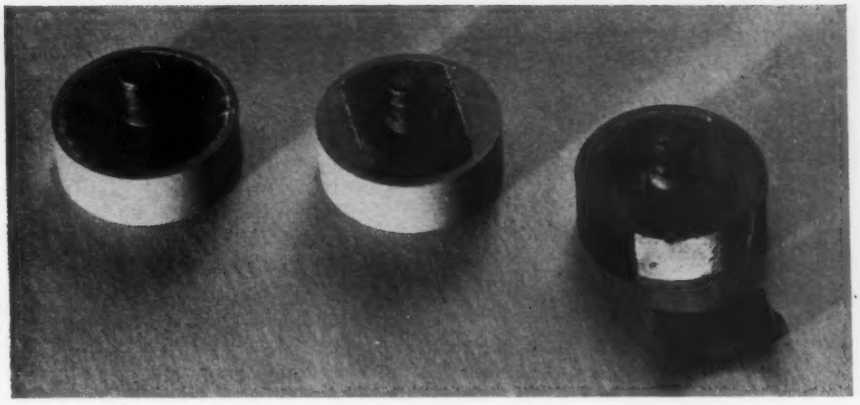


Fig. 1—Large insert surrounded by relatively thin molded section, left, compression molded of almost any phenolic material. Similar design which can be readily molded, right, cracks at corners of insert when ordinary molding material is used because of stress concentration. Special material, center, is required for satisfactory molding.

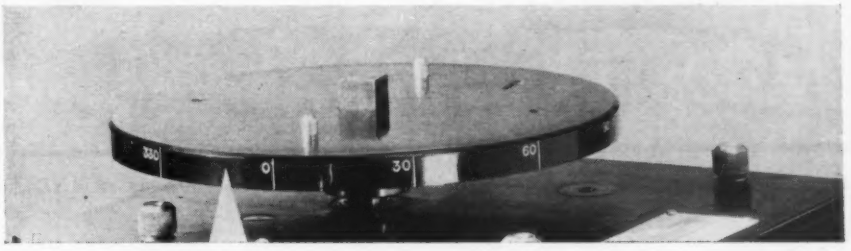


Fig. 2—Shrinkage was used to special design advantage in molding this turntable.

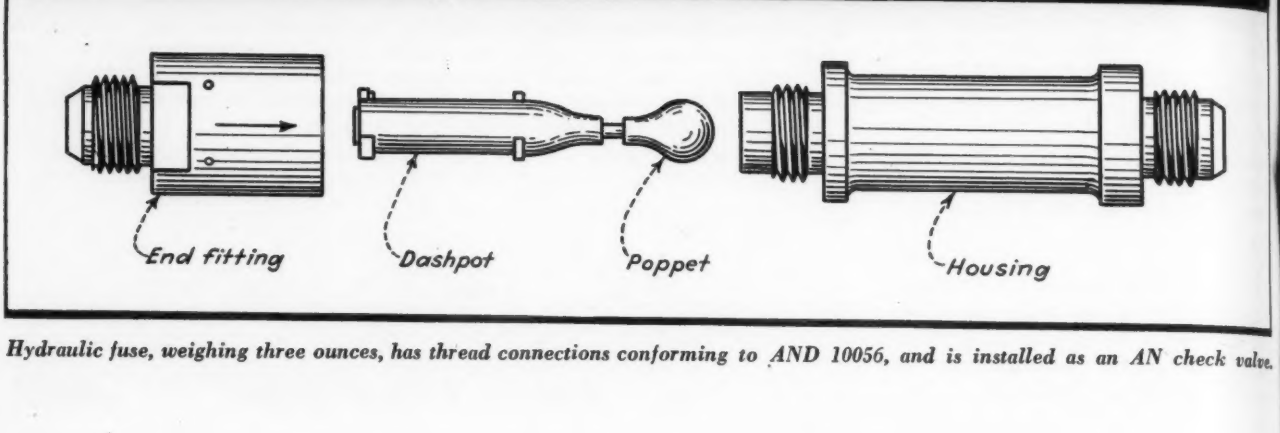
Table II—Shrinkage and Elasticity of Typical Phenolic Materials

Type Phenolic	Filler	*Shrinkage, in. per in.	Modulus of Elasticity × 10^6
General Purpose	Organic	0.007–0.009	1.0
Impact	Cotton flock cloth	0.003–0.007	1.0
Non-Bleed	Organic	0.008–0.010	0.9
Electrical	Mineral	0.002–0.005	2.0–3.0
Heat Resistant	Mineral	0.003–0.005	2.0
Special Purpose	None	0.009–0.010	0.9

* Lower values are for stiffer grades and higher values are for softer grades.

The turntable shown in Fig. 2 had to be marked very accurately since it was to be used on aircraft instrument testing equipment. To save the cost of machining each plate after molding, the marks and figures on the edges were included in the mold. Shrinkage of the material was especially measured so that the piece could be removed from the mold without stripping or defacing it. This required a partial cooling before removal of the piece from the mold. Consequently, production time was slowed but production cost remained less than if machining had been done as a separate operation. Such procedure was practical because of the relatively large size of the piece. For smaller parts it would not be practical.

For ordinary, simple shapes, in compression molding, general rules can be followed for shrinkage allowance, but in other cases experience in mold and insert design is still the guiding factor. Proper application of knowledge of shrinkage properties will eliminate much grief for the molder of the part, the manufacturer of the material and the buyer of the part.



Hydraulic fuse, weighing three ounces, has thread connections conforming to AND 10056, and is installed as an AN check valve.

Newly Developed Fuse Protects Hydraulic Lines

J. C. DE GRAAF and JACK BASKIN
Simmonds Aerocessories, Inc.

Discussion of function, design and application of the quantity-measuring type of hydraulic fuse including performance data, information on applications and behavior in service.

IN ANY hydraulic system, whether it be in aircraft, transportation or industrial equipment, the possibility of line rupture must be considered. Should a break occur in a line leading to an operating unit, not only will that unit cease to function, but the entire hydraulic system may be rendered useless through loss of hydraulic fluid supply. It may be possible to isolate the ruptured section through immediate closure of the selector valve, but in any event the loss of fluid will be serious. This is particularly true in military aircraft, where a principal objection to hydraulic systems is vulnerability to gunfire. In transport operation, vibratory stresses may cause failure of a line. Thus the advantages that a hydraulic system possesses—lightness in weight, reliability, economy of operation—are overshadowed by the threat of line failures which may make the entire system inoperative. Obviously, fusing can prevent system failures caused by ruptured lines.

The function of a hydraulic fuse is analogous to the electric fuse. During normal functioning of the system neither fuse closes off. When excessive current flows in an electric circuit, the electric fuse opens. In a hydraulic circuit, the hydraulic fuse fulfills a similar function, closing the particular line in which it is mounted when the quantity of fluid flow becomes too great. This avoids loss of hydraulic fluid.

The basic design of the quantity-type fuse recently developed is that of a normally open check valve in which closing operation is controlled by a dashpot fitted with a metering orifice. It is installed exactly as an AN check valve, with standard thread connections. Dirt is excluded by a built-in screen, of finer mesh than the calibrated orifice. Dirt cannot clog the screen because reverse flow dislodges particles clinging to the screen. Constructed of 24 ST aluminum and X4130 steel, the fuse weighs three oz. complete. A spring assists the return of the poppet, but reversal of flow will return the poppet to neutral position. The same is true of normal operation at low temperatures.

Any fuse, to perform satisfactorily, must operate uniformly over a wide

range of conditions. The predetermined volume of oil required to close it must remain substantially constant regardless of rate of flow, or oil viscosity. This is accomplished in the new fuse design by controlling the closing movement of the valve poppet with a dashpot. Fluid flowing through the fuse past the valve poppet produces a force on the poppet, tending to pull the poppet to its closed position. If the poppet is not retarded, it will close instantly, even at low rates of flow. However, the fluid, in order to escape from the fuse cylinder, must travel through a carefully calibrated orifice. Thus the force produced on the valve poppet is balanced by the resistance created by fluid flow through the dashpot orifice. By design the amount of force produced at the poppet is made exactly the same as the amount of resistance provided by the orifice. With such designed balance, the device acts as a true meter and the poppet seats only after a predetermined amount of fluid has passed through the fuse regardless of the rate of flow, or of the viscosity of fluid. For example, cold, heavy fluid produces a larger force on the poppet than warm fluid. This increased force, however, is completely balanced by the retarded flow of the heavy fluid escaping through the orifice in the dashpot.

The fuse is in effect a meter. The predetermined volume required to close the fuse is always slightly in excess of the nominal rating of the fuse. With rates of flow under 1 gal. per min. the fuse will not operate as there is not sufficient force to overcome resistance caused by a return spring and by normal friction. When a break occurs in the tubing the rate of flow will always be far in excess of the 1 gal. per min. minimum.

The fuse will not protect lines against slow leaks. This is because flows in excess of 1 gal. per min. are required to overcome the return spring and friction. Therefore the fuse will not isolate lines subjected to slow seepage of fluid caused by leaky fittings or leakage past cylinder seals. Generally, it is better to have the lines open with a slow leak and still allow operation of the cylinders. Because of the action of the internal dashpot rates of flow, as high as 20 gal. per min. do not affect basic functioning of the fuse.

Fuses are installed in the line to each operating unit and are mounted as close to the selector valve as possible to obtain maximum protection of the line. Fuses are generally placed on both the high-pressure and low-pressure lines. If either line is damaged, the other remains open allowing emergency operation in one direction only. The unit to which the lines lead must have a volumetric displacement not greater

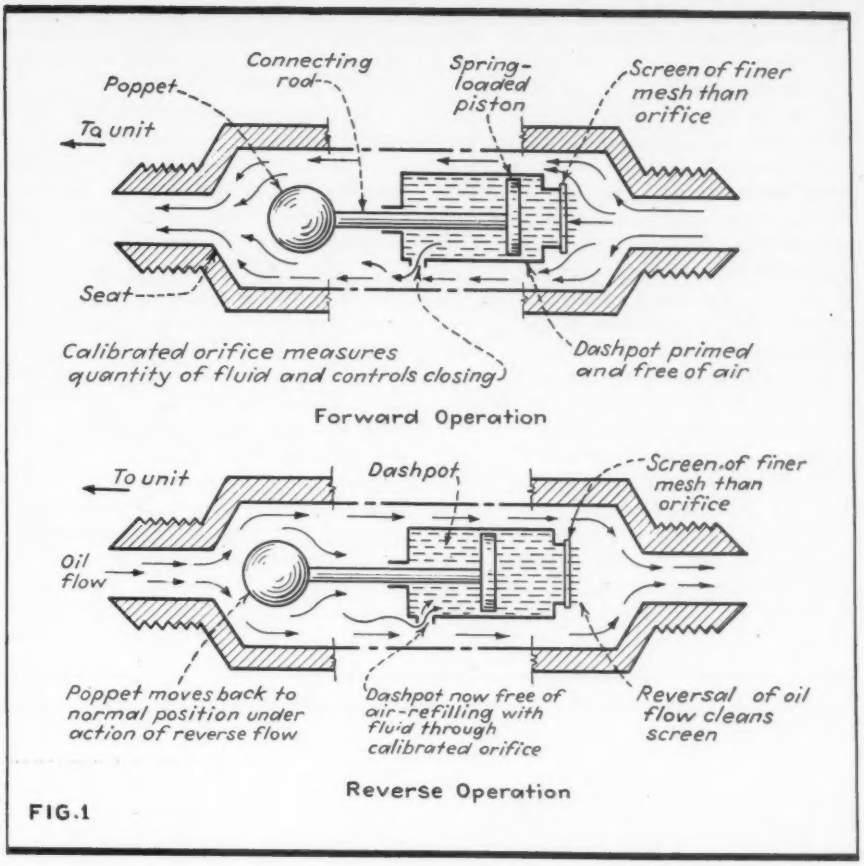

Poppet
Connecting rod
Spring-loaded piston
Screen of finer mesh than orifice
To unit
Seat
Calibrated orifice measures quantity of fluid and controls closing
Dashpot primed and free of air
Forward Operation
To unit
Dashpot
Screen of finer mesh than orifice
Oil flow
Poppet moves back to normal position under action of reverse flow
Dashpot now free of air-refilling with fluid through calibrated orifice
Reversal of oil flow cleans screen
Reverse Operation
FIG.1

Fig. 1—Schematic of fuse illustrating fundamentals of design and operation. At top position is shown normal operation; at bottom reverse flow.

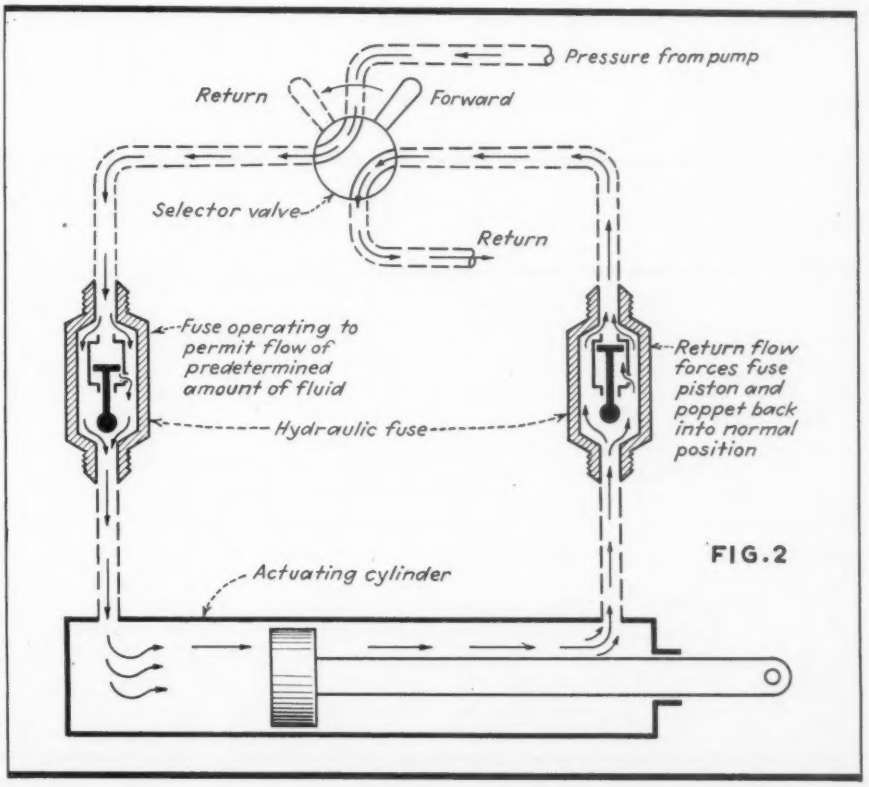


Fig. 2—Typical installation of fuses on supply and return to actuating cylinder. With selector valve in return position poppet in fuse at right moves downward to permit flow of predetermined amount, poppet in fuse at left is forced back into normal position.

than the rated capacity of the fuse. In other words, with a cylinder having a displacement of 18 cu. in., a 20 cu. in. capacity fuse must be used. With such an arrangement, during normal operation, there is never sufficient fluid flowing through the fuse to close it. In the event of line breakage, however, the flow will be unlimited and the fuse will shut off after a volume slightly in excess of the rated capacity has escaped. Only those lines in the system subject to two-way flow can be protected with a quantity-measuring fuse. If placed in the main pressure line, it would immediately close off.

When a restrictor valve is located between the selector valve and the fuse, the fuse will not close off if a line is severed if the restriction reduces flow under 1 gal. per min. The advantages of a restrictor valve can still be obtained, however, by placing it adjacent to the actuating cylinder. When the line is severed between the restrictor valve and the fuse, the fuse will close.

The fuse is not affected by back pressures, surges or by large amouuts of air left in the system by incomplete bleeding. Air in the lines has no effect on the fuse, except at the time of the original filling of the system. When the fuse is first installed it is completely full of air and as soon as the selector valve is operated it will immediately close. However, as soon as the pressure is released by returning the selector valve to neutral, or by reversing it, the fuse automatically re-sets and fills with fluid. When a new fuse is installed it is necessary, therefore, only to operate the selector valve a few times and then the usual bleeding operations on the cylinder can be carried out. If the cylinders are not bled, and a large amount of air remains in the lines and cylinders, the operation will not be affected inasmuch as oil is always present in the fuse body at the time of resetting.

Fuse Performance

The curves (Fig. 3) show the pressure drop with various sizes of fuse. Pressure drops are comparatively small and inconsequential. On a ¼ in. line, at a rate of flow of 1.2 gal. per min., the pressure drop is 5 lb.; on a ⅜ in. line, at a rate of flow of 3½ gal. per min., the pressure drop is 11 lb.; on a ½ in. line, at a rate of flow of 6 gal. per min., the pressure drop is 11 lb., approximately.

To predict fuse performance when an airplane pulls out of a dive, tests have been run to determine the time required to close the fuse when weights of from one to ten times the weight of the movable elements of the fuse were

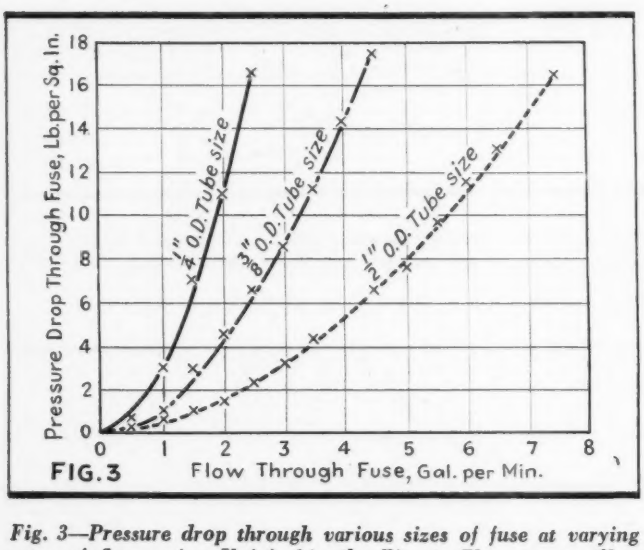


FIG. 3

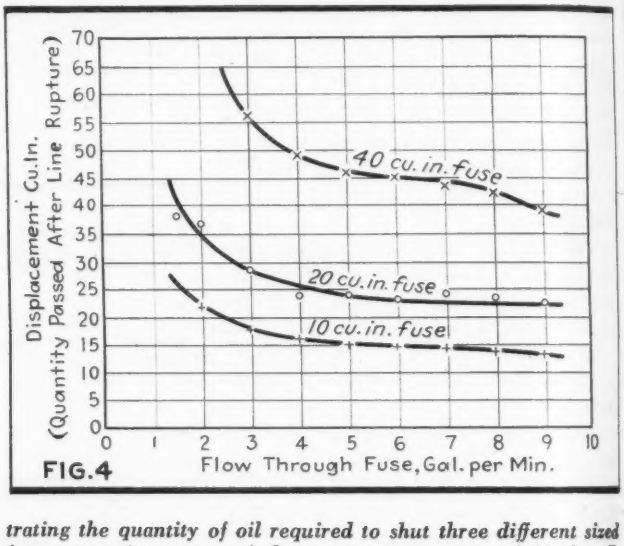

Displacement Cu. In.
(Quantity Passed After Line Rupture)
40 cu. in. fuse
20 cu. in. fuse
10 cu. in. fuse
Flow Through Fuse, Gal. per Min.
FIG. 4

Fig. 3—Pressure drop through various sizes of fuse at varying rates of flow, using Univis 34 oil. Fig. 4—Flow curves illustrating the quantity of oil required to shut three different sized fuses at various rates of flow at a temperature of 90 deg. F.

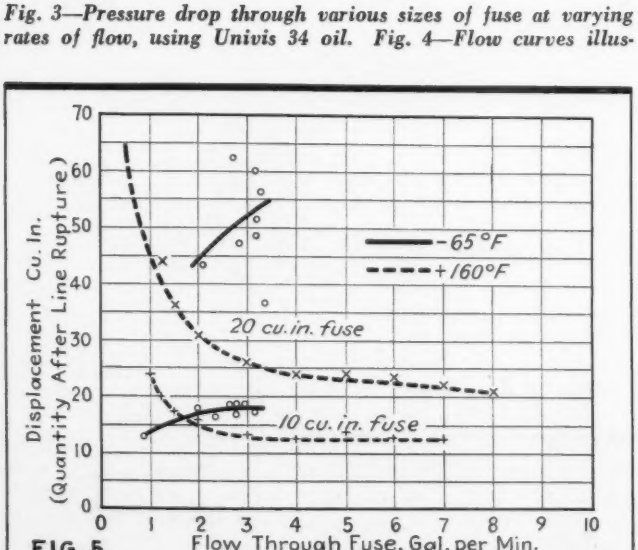


FIG. 5

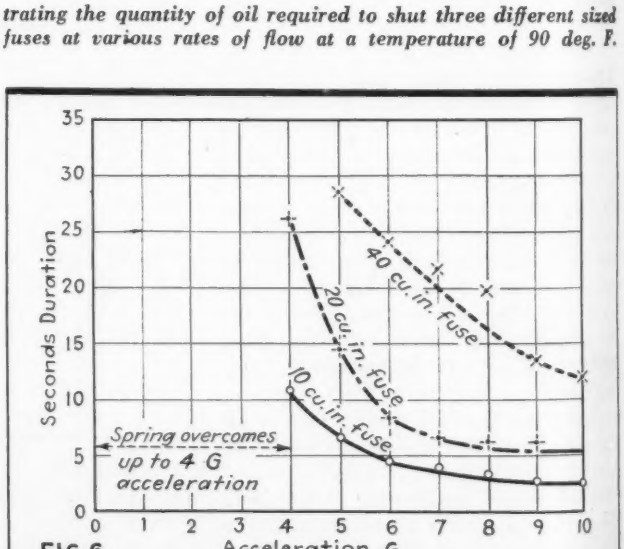


FIG. 6

Fig 5—Quantity of fluid required to shut three different sizes of fuse at various rates of flow, and temperatures of –65 deg. F. and+160 deg. F. Fig. 6—Length of time required by various accelerations to shut fuse in the event it is mounted in a downward position. In view of the rapid pilot "blackout" at high acceleration, the fuse would probably not close for the short pull-out duration. To cope with such a situation, the engineer can specify mounting at the fuse horizontally or vertically.

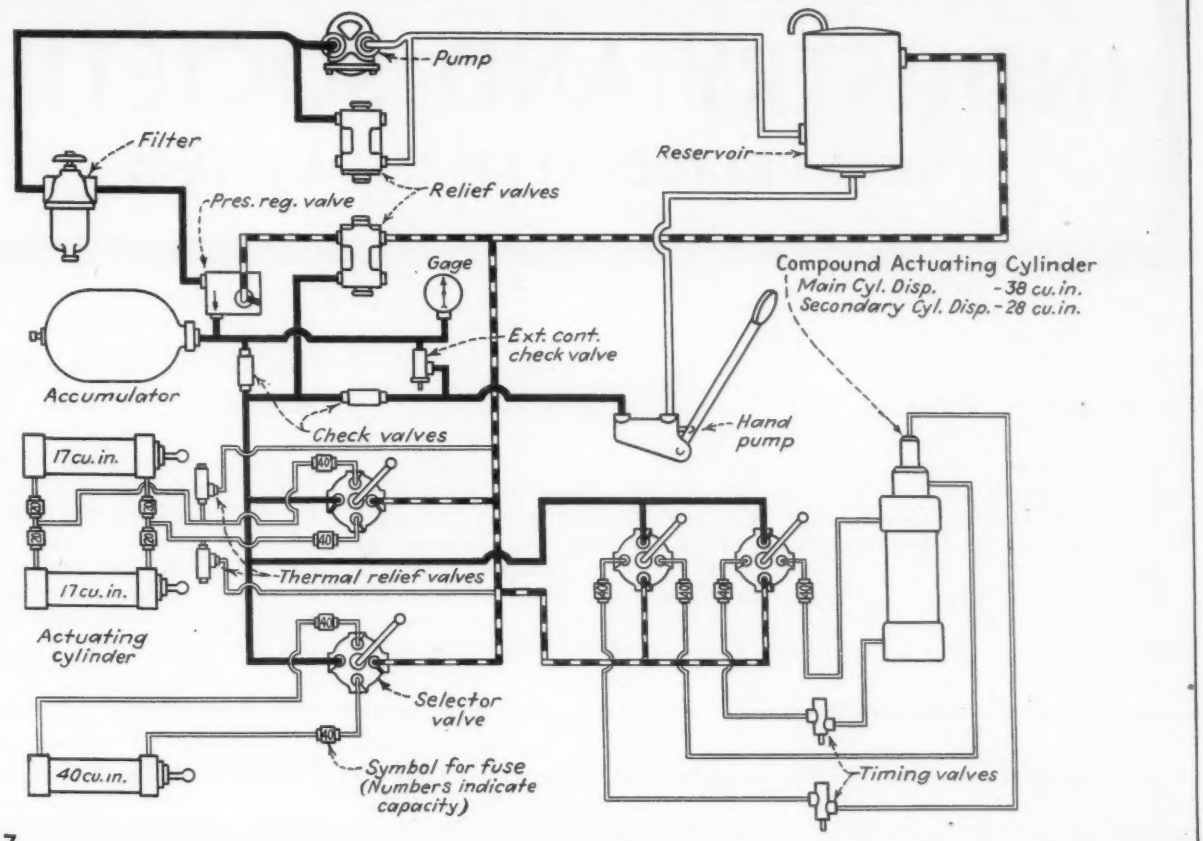


Fig. 7—Typical aircraft hydraulic circuit showing location of and sizing of fuses. Note that fuses are installed as close to selector valve as possible to obtain maximum protection of lines.

applied to the poppet, so as to get the values of gravity. Runs were made with weights from one "G" to ten "Gs" in increments of one "G." The starting point on each curve is the minimum value of "G," which would entirely close the fuse, as values below this would not close the fuse. The time required for the piston to travel to full stroke was recorded by an electric timer controlled by a hand button switch. These time values are plotted as ordinates, and the value of "G" as abscissa on the accompanying curves.

If deceleration affects fuse operation, the fuse can be mounted in the opposite direction of the force, or in the horizontal position. The spring in the fuse, if it is mounted with the poppet down, will overcome four "Gs" of deceleration. In excess of four "Gs" it becomes a matter of time required to close the fuse under such force. It must be appreciated that the effect of deceleration on the fuse should only be considered when a cylinder is open. If the fuse is mounted vertically with the poppet up, the poppet will close at a rate five percent slower than if mounted with the poppet down.

The end of the cylinder in the fuse has a $\frac{3}{8}$ in. bearing surface on which the shaft rides. This eliminates possibility of chattering when the poppet gets near the closed position. There is also an extra hole in the shaft. This is never exposed in normal operation of the fuse, and cannot be clogged with dirt. This extra hole, placed in the shaft in the event a line is ruptured when the poppet travels further than it does in normal operations, allows the balance of the fluid in the dashpot to be quickly expelled through this hole. This eliminates high-pressure chattering of the poppet when it is near a closed position.

New Fuse Developments

An extra orifice included in the fuse permits the dashpot to fill quickly on the return stroke of the poppet. A small ball check in the orifice prevents fluid from flowing into the dashpot in the forward motion of the poppet. Larger size fuses have been developed to take care of the larger actuating units. At the present time the Simmonds hydraulic fuse covers a wide range of applications, from 10 cu. in. to 120 cu. in. in line sizes from $\frac{1}{4}$ in. to $\frac{5}{8}$ in. The present fuse, which has been designed for ordinary aircraft systems, has a burst pressure of 3,750 lb. per sq. in. and a proof pressure 2,250 lb. per sq. in. A high-pressure fuse is also available for hydraulic systems operating in the higher pressures.

Recently, an aircraft company had trouble with the speed at which wing-folding cylinders closed. In normal temperatures the wings folded too rapidly, and as a result became slightly damaged because they struck against the locking pin. To alleviate this condition a fixed restrictor was placed in the line. However, with prevailing cross winds, or below-normal temperatures, particularly when the wing was loaded, retraction of the wing was very slow, often requiring manual assistance. Tests are now being run using a Simmonds hydraulic fuse in the lines leading to the wing-folding cylinder to act in the capacity of a delayed action restrictor and snubber when a certain volume of fluid has gone by the poppet. Holes are drilled in the poppet so that at any temperature the fuse will close, inasmuch as the fuse being used takes less fluid to close off than is required to actuate the cylinder. After the fuse has closed, the fluid then flows through the restriction formed by the holes in the poppet, easing the wings smoothly into the open position.

INDUSTRY AND SOCIETIES

NEWS • READER LETTERS • MEETINGS

Invasion Boats Made Of Synthetic Rubber

INVASION BOATS made of fabric impregnated with synthetic rubber are being produced in quantity by United States Rubber Company. Equipped with ingenious quick-release towing bridles, the boats are inflated from an air tank on the "mother" ship, towed by fast boats close to shore and released so that they beach themselves under their own momentum. Each boat carries ten men with full invasion equipment.

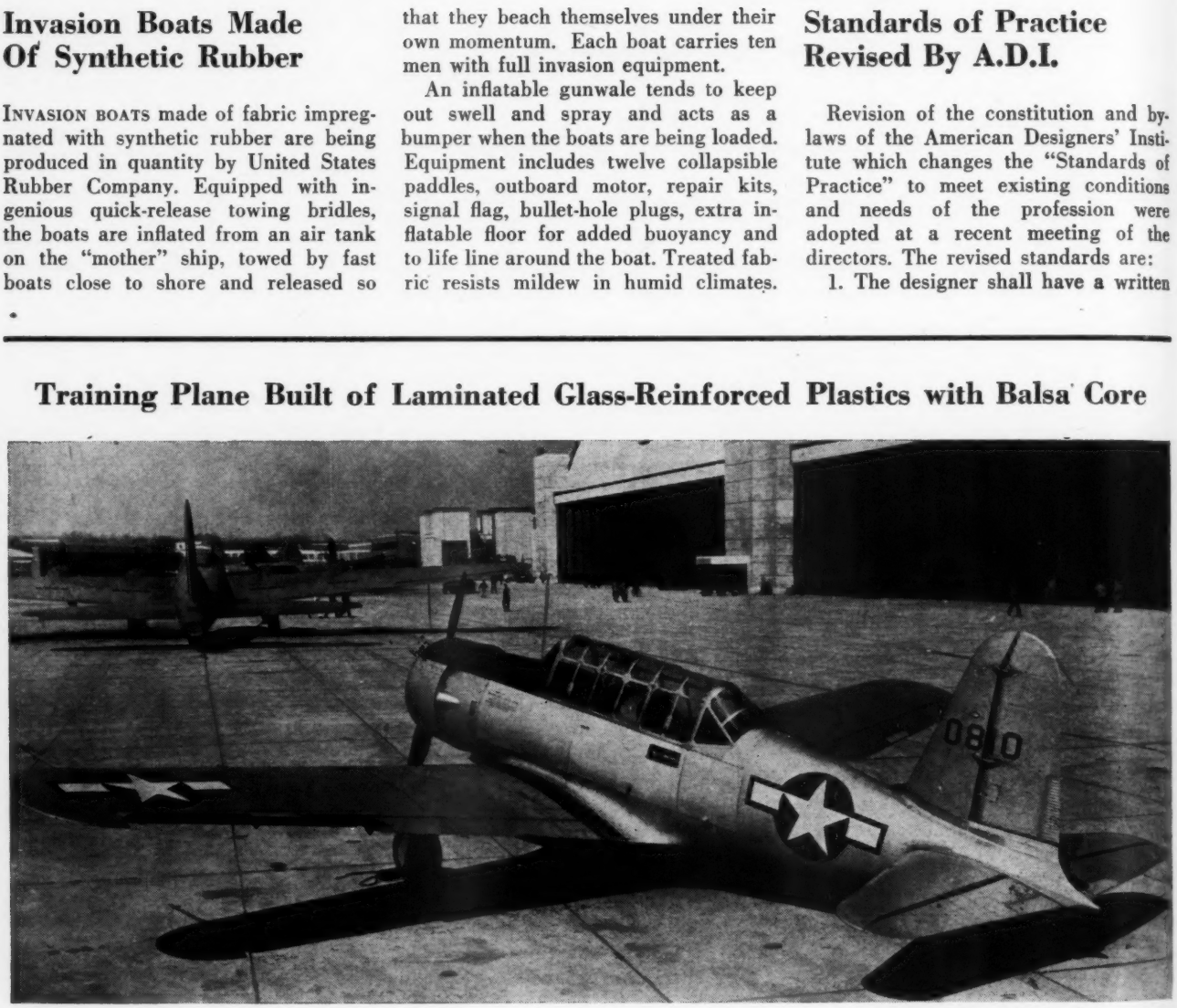
An inflatable gunwale tends to keep out swell and spray and acts as a bumper when the boats are being loaded. Equipment includes twelve collapsible paddles, outboard motor, repair kits, signal flag, bullet-hole plugs, extra inflatable floor for added buoyancy and to life line around the boat. Treated fabric resists mildew in humid climates.

Standards of Practice Revised By A.D.I.

Revision of the constitution and by-laws of the American Designers' Institute which changes the "Standards of Practice" to meet existing conditions and needs of the profession were adopted at a recent meeting of the directors. The revised standards are:

1. The designer shall have a written

Training Plane Built of Laminated Glass-Reinforced Plastics with Balsa Core



Owens-Corning Fiberglas Corp.

Fuselage, side panels and tail cone of this Army basic training plane are made of sandwiches consisting of outer layers of plastic reinforced with fibrous glass cloth and surrounding a core of balsa wood. This marks the culmination of a research program initiated by the Army Air Forces Materiel Command at Wright Field to develop a high-strength, lightweight plastic material that could be molded into intricate shapes without using high temperature, high pressure and expensive molds and that could be used for structural or non-structural aircraft parts. Ground destruction tests indicate that the glass-sandwich fuselage is considerably stronger than one made of metal or plywood. Under gunfire the material did not flower and high-explosive projectiles failed to detonate because of the low density of the material. In developing the material various combinations of glass fibers and resins were fabricated into ¼- and ½-in. laminated sheets and cured in a heated vacuum. Test results on cross-laminated specimens indicate that on a strength-weight basis the laminates compare with many metals in physical properties. Tensile strengths were found to be proportional to the amount of glass used and varied from 43,360 to 54,720 lb. per sq. in. Compressive strengths as high as 56,820 lb. per sq. in. were obtained. Impact strengths of unnotched specimens ranged from 28.82 to 31.25 ft. lb. Modulus of elasticity was 2,200,000 lb. per sq. in. and average specific gravity was 1.75. Strength values approximately twice as high can be obtained with parallel-laminated glass cloth.

agreement with his client to cover all necessary terms, specifications and confirmation of the agreement.

2. No order shall be accepted on speculation. There shall be no preparation of work on consignment.

3. All work shall be invoiced to the client at a fair profit. No work shall be done below cost.

4. Work stopped by a client after it has been started shall be billed on the basis of the time and effort expended.

5. All changes, revisions and additions not due to the fault of the designer shall be invoiced as a separate charge.

6. The designer shall accept no secret rebates, discounts, gifts or bonuses from others than his client.

7. All rejected sketches, designs, dummies or models must be returned to the designer as his creations remain his property; the accepted design being the only one paid for.

8. All sketches, dummies, plans and similar preliminary work shall be completed or carried to the final stage by the creator unless there has been an understanding to the contrary.

9. A creative design is an entity and when produced to a client's satisfaction and in accordance with his specification, shall not be altered, redrawn, mutilated nor used in separate sections without the artist's or designer's consent.

10. If the designer's work is used for more extensive purposes than originally proposed, he shall receive additional remuneration.

11. It shall be the right of every employer designer to claim authorship of every design created in his office unless otherwise arranged between employer and industrial designer.

12. There shall be no participation in contests unless the contest has been approved by the executive committee of the A.D.I. The A.D.I. will not countenance any contest which it deems contrary to the best interests of the public, the profession or any of those directly concerned.

13. The designer shall not maliciously injure the professional reputation, prospects or practice of a fellow designer.

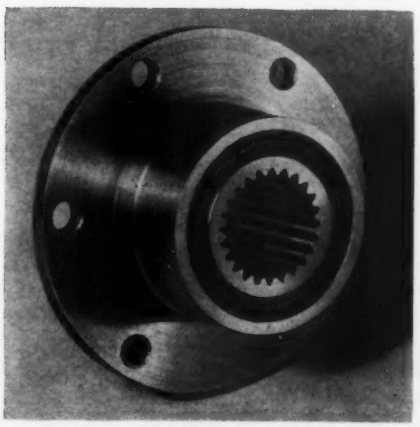
14. There shall be no plagiarism of designs, drawings, sketches, dummies of products.

New Engine Mount Requires Less Rubber

Reduction in weight and vibration in Flying Fortresses are advantages of a new type of rubber mount for aircraft engines, nine of which are used for each engine, developed by Goodyear Tire & Rubber Company. Because less rubber is used there is a saving of 15 lb. of dead weight, or 45 lb. on the basis of extra lifting capacity needed for original weight. Engine vibration is absorbed by a natural rubber sleeve in the mount. A plastic knuckle eliminates need for oiling or greasing. With the new mount, engines reach their vibration peak earlier than previous types of mounts, and often before flying operation ranges are reached. The new mounts are interchangeable with previous types.

Neoprene-Insulated Drive Eliminates Coupling

Separate flexible coupling is eliminated by the Neoprene insulation in this shaft coupling used on a 75-hp. engine-driven electric generator. Consisting of a splined inner sleeve, a flange and the synthetic rubber bushing, the coupling is designed to operate at 6,000 r.p.m. with 788 in. lb. maximum torque. The coupling stops transmission of noise, absorbs shock and impact and compensates for misalignment between drive and driven shafts.



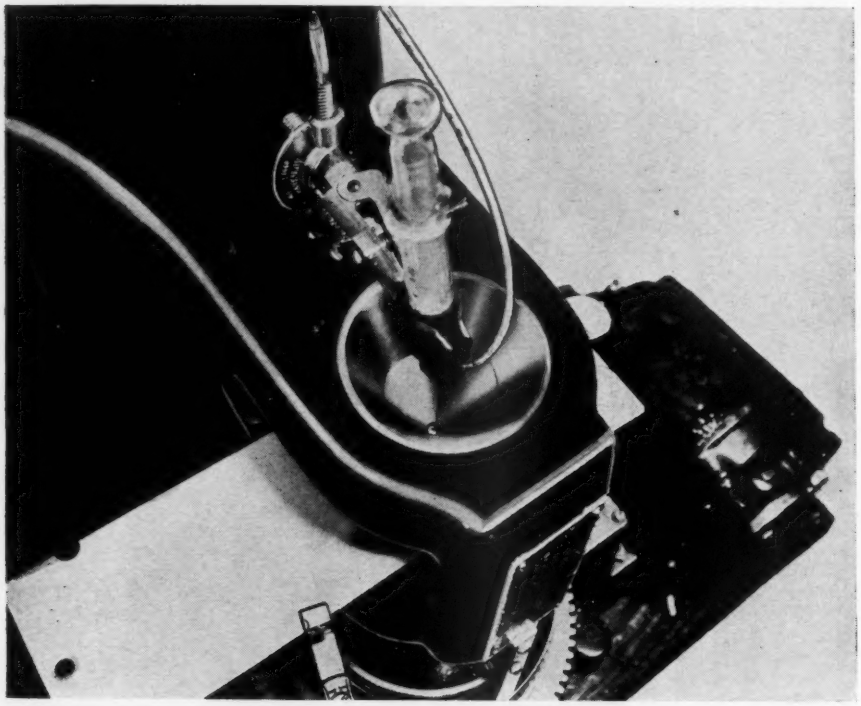
Bushings, Inc.

Glass and Asbestos Combined in New Textile

A COMBINATION of glass and asbestos fibers has resulted in a new textile material. The material is intended for applications requiring high strength combined with light weight, high abrasion resistance and resistance to high temperatures and corrosive fumes. Supplied by Owens-Corning Fiberglas Corporation, it is classified as an inorganic canvas or duck.

The textile is made by combining either glass and asbestos fibers to form yarn or glass and asbestos yarns in the weaving operation. The glass is responsible for high strength while the asbestos increases abrasion resistance. In fabric form it is used for gun boots; aircraft tail-wheel boots and, in the P-47 Thunderbolt, to protect retractable landing gear from the hot exhaust of the supercharger. In cord form the textile is used for shroud lines on military flares.

Determination of Coating Flexibility



By adapting a conventional Erichsen sheet-metal testing machine, flexibility of organic coatings is determined in Arco Company laboratories. The machine is mounted so that the observation well is vertical. Water is placed in the bottom of the well and the end of a needle is immersed in the water. The needle and the steel test panel are connected to a galvanometer. When the coating fails the water contacts the steel panel, completing the circuit and recording the failure on the galvanometer. The device is known as an Elongauge.

Activities Among Technical Societies

SPECIAL DEVICES EXTEND ELECTRONIC COUPLING APPLICATIONS

Ingenious coupling arrangements to hitch electronic power to unusual work loads are meeting special requirements for industrial heat-processing applications, Dr. Wesley M. Roberds, development engineer, RCA Victor Division of the Radio Corporation of America, said at the January meeting of the Philadelphia Section of the Institute of Radio Engineers. The variety of applications and special effects for which electronic heating may be adapted by tailor-made "harness," is virtually unlimited, he said.

Unique characteristics of high-frequency currents for induction heating of metals are, Dr. Roberds pointed out, tendency to travel on the surface of the metal and ability to concentrate large or closely controlled amounts of power in small or selected areas of the work piece, with split-second timing of the interval of application. This makes possible the heating of an object differentially—that is, to heat only a selected area or shell—for such processes as case-hardening.

"Specially-designed coupling devices are sometimes required to harness the radio-frequency power source to the object to be processed," the speaker explained, "the most efficient design for a given job depending on the size, shape and substance of the work piece, the effect desired, the frequency used and various other factors.

"Proper values of frequency, power and time are likewise determined by the nature of the work piece and process requirements. High frequencies must be used for very small pieces, for example, while lower frequencies are required to heat larger pieces.

"Again, the highest practicable frequency is needed for maximum control of the depth of the heated shell, while the lowest frequency consistent with good coupling and efficiency is preferable in processes where uniform heating throughout the work piece is desired. For differential heating, some techniques require a power concentration on the order of 75 kw. per sq. in. for an application interval of about 0.1 seconds.

"The special requirements of each application must be known and considered before proper values of frequency, power and time can be stated. These in turn must be determined before selection can be made of the most efficient methods and equipment for delivering to a specific work load the frequency and power concentration required for the particular process for which it is to be used.

"Since the requirements of a variety of possible work loads differ widely from those for an ideal load, it is almost impossible to apply specific ratings to electronic power generators, and such factors as frequency and the method of coupling are fully as important as the rated power output of the oscillator.

"For certain sizes and shapes of work, efficiencies of 1 to 5 percent can be considered high, while on other types of loads the same generator might have an efficiency of 60 percent. However, when one considers such advantages as the close control of processes, savings in man-hours and elimination of bulky ovens, an RF unit may well prove economical even on the 1 percent job."

Dr. Roberds described the design and performance of several types of transformers for coupling the RF generator to the applicator or work coil and discussed the various special types of work coils which have been found useful in solving typical basic problems in induction heating.

SAFETY COLOR CODE PROPOSED FOR INDUSTRY

Adoption by industry of a safety color code, consisting of a uniform system of six standard colors and symbols to indicate accident hazards, was proposed at the 15th annual convention of the Greater New York Safety Council by Matt Denning, director of trade and refinish sales, fabrics and finishes department, E. I. du Pont de Nemours & Company. The colors and symbols and their uses are:

High-visibility yellow, with alternate yellow and black stripes as the symbol, is proposed because it is visible at long distances and under poor lighting conditions. It is now standard on school buses, Navy life rafts and aviators' life jackets. It should be used for trucking equipment, aisle markings around hazards, edges of loading platforms and pits, railings, floorpan edges, conveyor parts at hazardous levels, aisle obstructions, protruding parts, curbings, dead ends, low beams, stairway approaches, floor elevation changes, chain-hoist blocks, loading buckets and risers of off-standard steps.

Alert orange, with an arrow or triangle

symbol, is applied to interior surfaces of electrical switch boxes, fuse boxes, power boxes and machinery guards, and to such exposed parts as pulleys, gears, cutting devices and rollers.

Safety green, with the cross symbol used on physicians' emblems and Army and Navy safety equipment, is proposed for first-aid rooms, stretchers, safety showers and cabinets for gas masks, respirators and medical supplies.

Fire-protection red, with a square symbol is applied to such fire-protection equipment as extinguishers, hose connections, apparatus, alarm stations, hose, hydrants, fire doors and fire blankets.

Precaution blue, and a disk symbol, borrowed from the railroads to identify apparatus not to be used, moved or started, is of interest chiefly to maintenance men.

Traffic white, gray or black, including a star symbol, is intended for traffic controls, storage areas, waste receptacles, aisle markings, corners and floor areas immediately surrounding waste receptacles.

PORCELAIN ENAMEL INDUSTRY STUDIES NEW PROCESSES

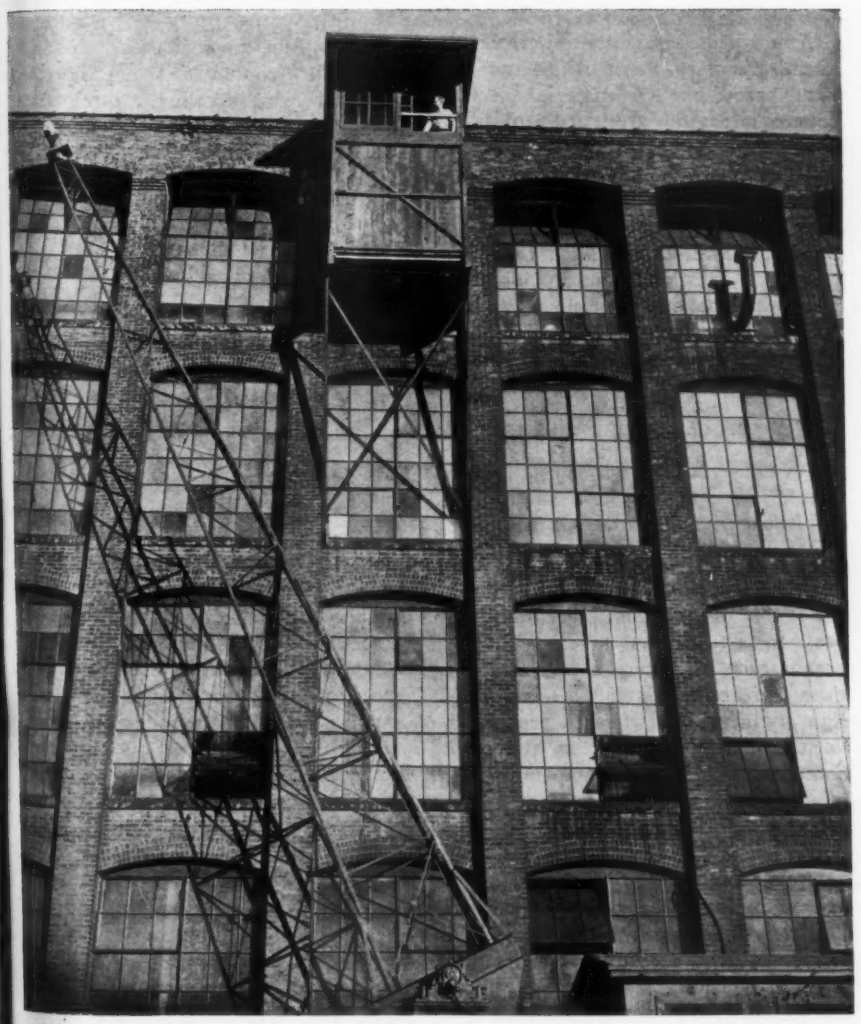
Results of research in other fields have led the Porcelain Enamel Institute to establish a committee on process development to study new manufacturing methods and to report on their adaptability to porcelain enameling. A specific program of inquiry has been laid out and one new process has been assigned to each committee member for further study. Subsequent meetings will be held to develop a final report to the industry and make recommendations for additional research work.

The committee has agreed that the processes of applying porcelain enamel are in need of critical examination because engineering advance in the finishing field has been rapid and processes not subject to continuous research will be superseded in future production.

Electrostatic and induction heating for drying and fusing are two suggested changes. These methods of heating may have revolutionary effects upon the application of porcelain finishes. Use of multiple or repeat tanks in cleaning operations and electrolytic cleaning has been suggested. Technicians agree that better cleaning is important and point to the results that have been secured for other coating processes.

Atmospheric control of furnaces is progressing rapidly, especially where the protective nature of the porcelain-enamel coating is important. Air cleaning, both as a matter of process control and for the recovery of materials, is receiving increasing attention because the proper preparation of air for spraying improves the application of the coating. Electrolytic precipitation of porcelain enamels in spraying, according to many engineers, will result in a reduction of the materials used. It will also make application much more complete and uniform, and tend to reduce the loss resulting from irregular or thick coatings.

Tower Simulates Motion of Ship's Mast



Electrical apparatus to be mounted on the superstructure of ships is tested by Westinghouse engineers on this rocking tower that simulates the motion of a ship's mast. The tower is 50 ft. high from the center of oscillation and weighs 600 lb. The counterweight weighs two tons. Driven by a 35-hp. motor and an oil-well reduction gear unit, the structure can be rocked at varying speeds from 4.5 to 10 sec. through an arc 45 deg. on either side of vertical.

Do You Know That—

PRECISION TUBING with an outside diameter of 0.0019 in. and inside diameter of 0.0004 in. is being made of nickel. (21)

BETWEEN 950 and 1,000 lb. of copper and its alloys are contained in an M-4 tank. (22)

Meetings

American Electroplaters' Society—Annual meeting, June 12-14, Hotel Cleveland, Cleveland, Ohio.

American Society of Mechanical Engineers—Applied mechanics division meeting, June 16-17, Chicago, Ill.

American Society of Mechanical Engineers—Semi-annual meeting, June 19-22, William Penn Hotel, Pittsburgh, Pa.

American Society for Testing Materials—Annual meeting, June 26-30, Hotel Waldorf-Astoria, New York, N. Y.

New Books

Illustrated Technical Dictionary

MAXIM NEWMARK, *editor.* 352 *pages,* 6x9 *in., green clothboard covers. Published by Philosophical Library, Inc.* 15 *E. 40th St., New York, N. Y. Price* $5.

Definitions of numerous technical and trade terms are given with illustrations for many of them. Standard definitions established by societies or associations have been used wherever possible, but some of the definitions are inaccurate or limited in scope. Much value can be gained from this dictionary if possible inaccuracies are kept in mind.

Engineers' Dictionary

LOUIS A. ROBB. 423 *pages,* 5½x7¾ *in., maroon leatherette covers. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y. Price* $6

More than 25 years' accumulation of Spanish-English and English-Spanish equivalents have resulted in this volume, the purpose of which is to facilitate translation of engineering terms used by South and North American engineers. The principal field covered is civil engineering in all its branches, which necessarily include many mechanical and electrical engineering terms. No attempt has been made, however, to deal thoroughly with terms other than civil engineering and construction.

Aircraft Production Illustration

GEORGE THARRATT. 201 *pages,* 8½x 11 *in., blue clothboard covers. Published by McGraw-Hill Book Co.,* 330 *W. 42nd St., New York* 18, *N. Y. Price* $3.50.

One of the most complete works on the subject up to this point, this book is intended to present a brief but all-inclusive story of production illustration for the benefit of management, to present suggestions for the introduction of such drawings into existing engineering and manufacturing organizations, to serve as a reference manual for supervisors of production illustration departments and for teachers and to serve as a training manual for students. Perspective layout, technical sketching and the basic principles of production illustration are covered. An appendix was added to cover developments since the material in the book was originally compiled. It also includes short cuts and alternate methods, stations identification chart, loft breakdown, summary of the organization and functioning of production illustration in the operations of Lockheed Aircraft Corporation to show the advance that has been made in the past few years in the utilization of production illustration by a representative manufacturing concern, partial list of production illustration schools and instructors and partial list of users of production illustration in the United States and Canada. More than 200 illustrations help to clarify the principles presented. The book belongs in the library of any engineer who has occasion to use or make pictorial drawings.

Synthetic Resins and Rubbers

PAUL O. POWERS. *Published by John Wiley & Sons, Inc.,* 440 *Fifth Ave., New York, N. Y.* 296 *pages,* 5½x8½ *in., green clothboard covers. Price* $3.

A new briefing manual describing the chemistry of synthetic resins and rubbers based on the material used in courses in plastics given at Franklin and Marshall College. The book should serve as a useful reference text for engineers desiring to investigate the mechanical structure of these synthetics. Subjects covered include theories of polymer formation, condensation, polymers, vinyl polymers, synthetic rubbers, resins from natural products, and applications of synthetic resins.

Materials and Processes

JAMES F. YOUNG, editor. 628 pages, 5½x8⅜ *in., green clothboard covers. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y. Price* $5.

Purpose of this book, according to the preface, is to present in one volume a broad study of materials and manufacturing processes for the benefit of design engineers and thus to provide information directly useful in the selection of materials. It is intended for both reference and classroom work. The editor is a member of the Engineering General Division of the General Electric Company and the book, one of a series written in the interest of the General Electric Advanced Engineering Program, has been prepared from lectures given in a general course in materials and processes conducted under the program. Chapter headings of the materials section include the nature of pure metals; alloys; mechanical properties of metals; iron and steel; non-ferrous metals and alloys; heat-treatment; corrosion; magnetic properties of materials; electrical insulation; and plastics and their molding. Under the section on processes there are chapters on casting processes; powder metallurgy; hot-working processes; cold-working processes; welding and allied processes; machining; gaging, inspection and quality control; and cleaning, plating and finishing of metals. A thorough job of collecting and presenting a wealth of information has been done.

Engineering Drafting Problems

KENNETH E. QUIER. 10 *pages and* 80 *plates,* 8¼ x 10¾, *loose-leaf binding. Published by Harper & Bros.,* 49 *E. 33rd St., New York* 16, *N. Y. Price* $2.50.

Carefully selected problems to cover both the elements of engineering drafting and professional problems in mechanical, civil, chemical and electrical engineering are presented. They are organized topically and illustrate basic principles as well as practical industrial applications. Ability to visualize objects in three dimensions is emphasized. The entire content of the ASTP course in engineering drawing is incorporated, including jigs and fixtures, punch and die works, cams and gears, springs, and lofting principles applied to airplane fuselage and ship contour lines.

Angular Spacing Tables

WERNER F. VOGEL. 233 *pages,* 8½ x 11 *in., black plastic-coated covers. Published by Vinco Corp.,* 8855 *Schaeffer Highway, Detroit* 27, *Mich. Price* $10.

The included angle between any point of beginning and any one or more divisions of a circle up to and including 200 divisions can be found in the tables comprising this book. The angle is given in degrees, minutes and seconds, with the decimals of seconds computed to three places. Other useful data are presented in the appendix. Fundamental dividing angles are listed in degrees, minutes and seconds; in degrees and decimals of the degrees; and in circular measure (radians). Conversion tables for minutes and seconds to decimals of the degree, and vice versa, are given. Multiples and fractions of π and $1/\pi$, and angular equivalents of N times $\pi/180$ and N times $180/\pi$ are included. Values for π and $1/\pi$ carried to 70 places are given. This value for π is the only one in the whole book not computed by the author himself. Each computation was checked with extreme care to prevent errors. Dr. Vogel, who is a member of the faculty of Wayne University Engineering College, wrote four articles presented in PRODUCT ENGINEERING during 1941 which dealt with new methods for exact determination of crank mechanism motions.

THE COST OF
Tomorrow's Peace

Today peace-loving Americans are united with thirty-three other nations in a common objective of destruction.

Millions of our fine, young men and women find themselves invading foreign lands in order that their own shores may be spared, and their free way of life preserved.

Their sacrifices will be great. Their job will be well done.

But what of the job they will expect of us when they have finished theirs . . . the job of turning their hard-won victory into a lasting pattern of peace?

Can we come up to their great expectation? We must realize that this is the last opportunity of our generation. We must do a better job of it than we did in the Twenties and the Thirties.

We have our backs to the wall, and the scars of World War I and a thirteen-year depression still are upon us. The final test of our way of life is at hand!

As we look over our shoulder into the immediate past, we see little to encourage us. But we also see much to make us pause. We see a tremendous fighting machine, created in a matter of months by the miraculous organization of our resources.

We, the largest of the peace-loving nations, have overnight become masters at the business of waging war. Today, as a result of the coordination of industry, labor, and government, we are producing ***for war alone*** as much as our total normal production for peace.

* * *

We have amply demonstrated our ability to harness the vast productive capacity we possess. Why cannot these resources, which we have organized so efficiently for the destruction of life and property, be directed toward the destruction of the causes of war?

May not the patriotic and emotional strength and the unity of action which have been stimulated for the purpose of winning the war be directed, at least equally well, toward the attainment of world peace and international harmony?

If they are not so directed, what lies ahead but another war? And how can America, in a world that is so rapidly shrinking in size, avoid involvement in ***any*** of tomorrow's conflicts?

International peace is an ambitious dream and its price is high, but the price of war is even higher. Our world cannot long survive the periodic waste of its human and material resources.

Our country can be the most potent single force in bringing about the international understanding that leads to peace, in developing the unity that will make the most of the ample resources nature has provided everywhere.

* * *

There is no unity in selfishness. There can be no unity if any one of the great powers fails to do its part in determining and eliminating from the world the basic causes of aggression.

These basic causes stem from greed and the suppression of opportunity for individual progress; for self-preservation is the first law of nature.

Mussolini's dramatic march on Rome in 1922 was made possible by disillusioned veterans of World War I who could find no jobs and whose future held no promise. Some of Hitler's most

determined followers came from the same ranks.

Men denied the opportunity to make a living, for themselves and for their children, are easy prey to false doctrines and dangerous "isms."

In any realistic appraisal of our domestic problems—economic, labor, racial—it is clear that we can solve them, not by waiting until we reach some utopian accord, but by making a series of compromises. We do this because we know how discord can impair the very roots of private enterprise, self-government, and self-discipline—the essentials of a dynamic democracy.

Similarly, peaceful reconstruction of our world economy depends on the ability of nations to reconcile their differences in a series of working agreements.

If we in the United States want lasting peace and if we want to preserve our democratic way of life, we must take over our full share of the task of initiating these compromise measures. Acknowledging our inescapable responsibility as the greatest economic and military power in the world, we must attempt to insure the free flow of world trade, and develop—with profit for both parties—backward areas abroad as well as at home. And we must do this by making all nations share the responsibility, not by allowing ourselves to be manoeuvered into being an international Santa Claus.

With our allies, we will have to see to it that the devastated portions of the world rehabilitate themselves as quickly as possible; that practicable and realistic trade and economic relations between nations are developed; and that the energies and productive capacities of these nations are set free to function in a climate that is favorable to the growth of free enterprise and individual initiative. As the most powerful economic force on earth, we have the most to gain and the most to lose at the peace table; and we must never forget that with our power comes responsibility.

We cannot hope to solve all of the problems of all nations—nor even all of our own—but our way can become the way for more of the world's humanity. Our strength can become the guiding spirit of the smaller nations.

* * *

In the development of a sound American foreign policy, let us take care not to attempt to control the destinies of other nations. Let us remember that we must set the example of self-determination of independent, free peoples.

Freedom is essential to international peace; and free competition—whether it be between individuals, between businesses, or between nations—is the mainspring, the synchronizer, and the preserver of freedom. For competition always is synonymous with private enterprise.

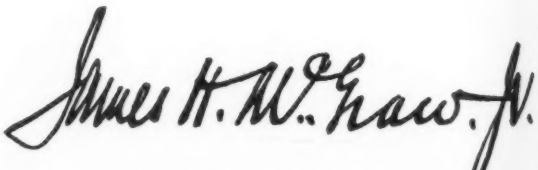
We are not a covetous nation. We have no territorial ambitions. Our international commercial aspirations are dominated by the conviction that we have a great stake in world unity and world prosperity. We know that we can no longer live apart from other nations and that we cannot ignore the fundamental elements which affect the well-being of other countries.

Our foreign policy must encompass a world of trade, and help develop it.

We dare not blunder in the execution of that foreign policy if the American way of life is to survive. A democracy resolved upon isolation is doomed in the world of tomorrow.

Let us resolve that out of this devastating catastrophe we shall emerge with fuller understanding and greater determination to build the kind of world which can materialize only if this country has the vision and the will to see it through.

We still are free to decide our own fate—still free to shape our own future. We still are free to preserve the liberty and happiness that has made our country the hope of the world.

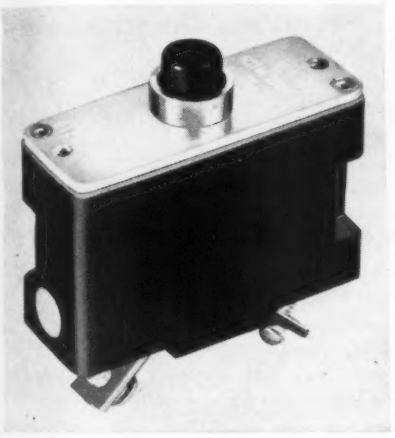


President, McGraw-Hill Publishing Company, Inc.

NEW MATERIALS AND PARTS

Push-Type Circuit Breaker

Low-voltage circuits that do not require switches can be protected with the Class 9310 manual reset circuit breaker. Although especially designed for aircraft use, these devices are also suitable for boats, tanks and other mobile units having power sources up to 30 volts d.c. A bimetalic trip element gives time limit protection against small momentary overloads as well as instantaneous protection on heavy overloads and short circuits. After tripping, the breaker is reset by depressing the button to its farthest position. The



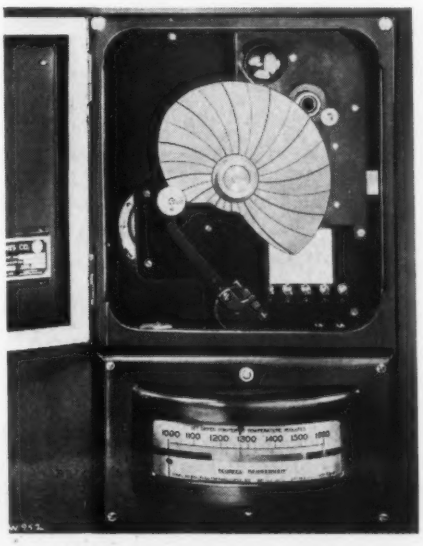
unit is available in 5- to 50-amp. sizes and is built in accordance with Navy specifications. All devices are equipped with luminous indicating rings visible in darkness, with a red indicating ring for daylght indication. Regulator Div., Square D Co., 6060 Rivard St., Detroit, Mich.

Timing Mechanism

Production of the process timing mechanism built into Fulscope temperature or pressure controllers has been resumed after being suspended since the beginning of the war. The process is started manually by adjusting the instrument for the desired time period. Timing begins when the apparatus reaches the desired control point. At the end of the timed period the mechanism automatically ends the process. Several variations of the instrument are available to cover a wide range of specific applications. It is interchangeable with the five different types of Fulscope control—fixed high sensitivity, adjustable sensitivity, adjustable sensitivity with automatic reset, adjustable sensitivity with pre-act and adjustable sensitivity with pre-act and automatic reset. Taylor Instrument Companies, P. O. Box 110, Rochester, N. Y.

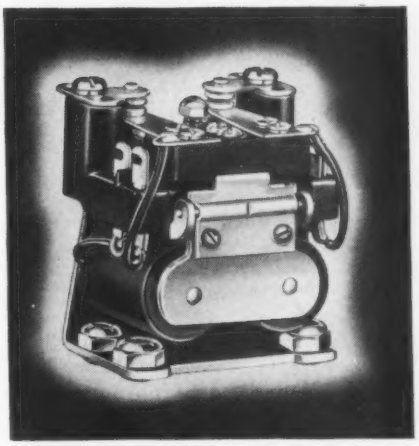
Temperature Regulators

Automatic regulation of processing temperature is the purpose of electronically operated Chronotrol instruments. The temperature cycle is cut on a disk, the rotation of which by a synchronous motor moves the temperature setting lever of the control instrument. Twenty-five models are available, including ten for proportioning control and others for two-position, on-off and three-position, on-intermediate-off control for high- and low-temperature applications. Thermometer models are available in recording as well as indicating types. Frequency of oscillating current flowing between pick-up coils, mounted on the temperature-control setting index, is changed when a control flag mounted on the pointer or pan arm is moved between the coils by a temperature rise, or is moved from between the coils by a temperature drop. This frequency change governs the output current of a vacuum tube which opens relay contacts that operate fuel valves or switches. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.



Dual Coil Relay

Through use of double-coil construction, power consumption of Model BOY relay has been reduced so that this type of unit can be applied to plate circuits where limited current is insufficient to operate a single-coil power relay directly. The two coils can be connected



in series for operation at one voltage and in parallel for a second voltage, or one coil can be used for operation while the other is used for holding. Semi-balanced armature construction is featured, and the unit is built to withstand 10G. The coils are sealed with cellulose acetate. Dimensions are 1⅝x1⅞x1½ in. and weight is 5 oz. Allied Control Co., 2 East End Ave., New York 21, N. Y.

Gold-Plating Process

Higher efficiency than with prepared salts is claimed for the Trushade process of applying industrial gold plating. Flexibility of application and elimination of loss in cutting down gold are other advantages mentioned. Trushade 24-kt. gold, and Trushade hard and 14-kt. alloys are used, all suspended in aqueous solutions. The for-

mer is for use in preparing 24-kt. and alloy solutions. The latter are used in conjunction with 24-kt. gold in preparing alloy plating solutions. Tests based on government specifications show acid resistance up to 3 hr. for a 70-sec. application. Alrose Chemical Co., Providence, R. I.

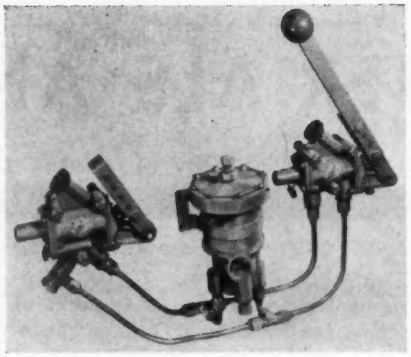
High-Pressure Hose Clamp

Strength and flexibility are features of a flexible double-strap hose clamp for high-pressure installations. The clamp is so designed that a single length will operate from the maximum possible with respect to circumference down to ⅜ in. dia. In addition, any number of clamps can be connected

end-to-end to surround large diameters. In this case the take-up of the single clamp is multiplied by the number of clamps used. The clamp can be installed after the hose is in place. Actus Products Co., Mt. Vernon, N. Y.

Hydraulic Control

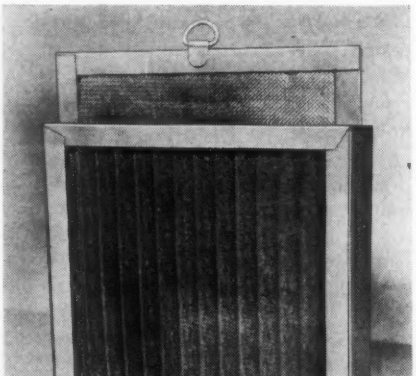
Recent improvements in Isodraulic remote controls include elimination of the diaphragm and auxiliary chamber of the equalizer unit and addition of synchronizing screws bypassing the pistons of the "Master" and "Slave" units, which permit bleeding and filling the system at one point without breaking any connections. This also provides rapid indexing of the lever positions. The two-line hydraulic system provides accurate response at the "Slave" unit to motion in either direction initiated at the "Master." It is now available with or without an integral lock, which in the "Slave" unit of the irreversible system maintains the selected position against load and vibration. Locking system and piston design have been improved to reduce the handle load to



4½ lb. for the irreversible system and 2½ lb. for the reversible system, using an 8-in. lever. The units can be mounted in any position and at varying elevations. Stacking width of "Master" and "Slave" units is 1¼ in. Total weight of the three units is less than 3¼ lb. Adel Precision Products Corp., Burbank, Calif.

Oil Separator Filter

Fire and health hazards from oil thrown into the air can be reduced by the use of Type R-56B oil separator filter. Installed in a ventilating system the filter removes oil entrained in the air, but does not remove oil smoke or liquids in a vapor state. The unit consists of a permanent, viscous impinge-



ment filter and a removeable oil-collecting medium. The filter panel is available in standard sizes. Air-Maze Corp., Cleveland 5, Ohio.

Flexible Insulating Varnish

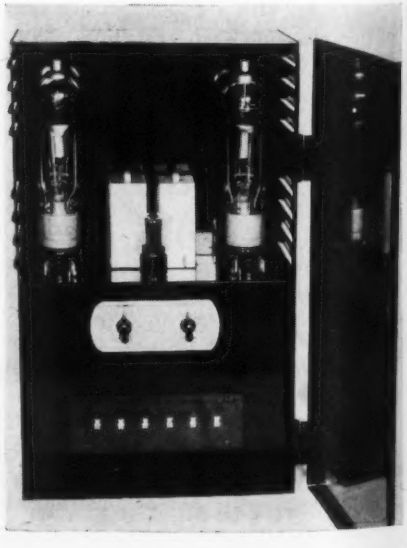
Development of R-851 flexible insulating varnish, designed for applications that demand exceptional lead wire flexibility in addition to high mechanical strength, has been announced. The varnish is also said to be suitable for coating armature and stator coils that will be stored for long periods before assembly. It is a clear baking varnish that dries throughout when baked at 135 deg. C. The varnish is oil, water, acid, and alkali resistant. It is suitable for electrical equipment that is wound with glass-covered wire and designed to operate at high operating temperatures. Sterling Varnish Co., 188 Ohio River Blvd., Haysville, Pa.

Solderless Tube Caps

Designed for heavy-load, high-temperature operation on power tubes, solderless tube-cap terminals are made in various metals for operation in any range of temperature. Hot-electrotinning resists corrosion on all types. Diamond Grip caps are for use on insulated wire where an insulation support type of terminal is required. Standard Type B units can be used on either insulated or non-insulated wire. Each type is available as an individual item or can be ordered as an integral part of a complete lead built to specifications. Aircraft-Marine Products, Inc., 1591R N. Fourth St., Harrisburg, Pa.

Electronic Timers

Two electronic timers, designated Series A and Series B have been announced. The former is especially suited for short-time operations of 45 cycles or less and is accurate in the ½-cycle range. It can also be used as a contactor for loads of ½ kva. or less. When used as a timer to control a large contactor, any amount of power can be controlled through either a mechanical or an electronic-tube contactor. Series B, illustrated, has a control range from ½ to 45 cycles. It is also a contactor for loads up to 15 demand kva. and can be used as a heat control



from 1 to 100 percent in stepless variation. Dimensions are 12x8x4 in. for Series A and 20½x12½x7 in. for Series B. Weights are 10 and 30 lb., respectively. Electronic Products Co., Geneva, Ill.

Rotary Air Motor

For use where explosive or inflammable gases or materials are present, a series of motors operated by compressed air is available in a wide range of speeds and horsepowers. The compressed air used may vary from 1 cu.ft. per min. up

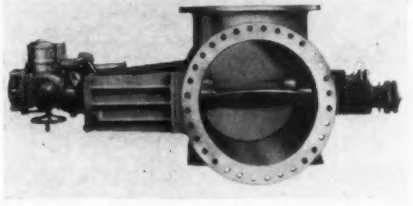
and the pressure from 10 to 100 lb. per sq.in. Horsepower ranges from 0.03 upward, and the speed can vary from 50 to 1,800 r.p.m. The motors are controlled by an air valve and are reversible. Leiman Bros., 128-28 Christie St., Newark, N. J.

Furane Derivative Resin

Low water absorption, insolubility after activation in any solvent or combination of solvents, high electrical resistivity, stability in storage and handling and ease of workability are characteristics of Duralon resin, derived from furane. In its pure form the resin is a heavy, viscous, dark maroon liquid. Catalysts and mild heat convert Duralon to a hard, dense, black substance. Varying physical, chemical and electrical properties can be developed in the base resin by incorporation of fillers and lubricants. In certain stages Duralon can be readily machined. The resins are soluble before activation in many inexpensive hydrocarbons as well as in ketones and chlorinated solvents. Preliminary studies indicate that Duralon has desirable molding possibilities but its immediate importance is as an impregnant, as a laminating and bonding agent, or as a protective coating material. Surface characteristics range from a high gloss to a crinkle finish. Solutions can be applied by conventional methods or they can be used for impregnation of porous and fibrous materials such as stone, cement, plywood, asbestos and glass fibers. Solutions can also be used as a bonding agent for such materials as abrasive compounds and powdered metals, or for adhesive bonding of fibrous materials. Prior to the application of heat, Duralon coatings are soft and flexible. As heat is applied (a mild bake is usually sufficient) the coatings remain thermoplastic up to a point, after which they become increasingly thermosetting, depending upon the type and extent of activation. After baking, Duralon coatings are hard and somewhat more brittle than thermoplastic coatings. They have notable resistance to abrasion, water, solvents, nonoxidizing acids and alkaline materials. Products made from Duralon resins apparently retain many of their desirable properties at temperatures in excess of 400 deg. F. U. S. Stoneware Co., Akron, Ohio.

Three-Way Valve

Simplified design and quick action of the modern butterfly valve have been applied to the Type 604 three-way valve, designed for quick interchange and mixing service for pressures from 15 to 900 lb. per sq. in. at elevated temperatures. It is adapted to manual



control as well as power operation. Dual-finned lubricated stuffing boxes are provided and the unit is operated by an electric motor. Weight is 9,500 lb. R-S Products Corp., Wayne Junction, Philadelphia 44, Pa.

Electronic Relay

Operated by any material having a resistance of from 0 to 500,000 ohms, or greater, if necessary, an electronic relay is especially suitable for controlling liquid levels in tanks and boilers, sorting metallic parts by size, detecting broken threads in textile machines, and

as a limit switch that operates on light pressure. The relay consists of a standard-type electronic tube, a supply transformer and an electromagnetic relay, all mounted in a weather-resistant inclosure suitable for wall or machine mounting. In operation, an electromagnetic relay in the device is kept energized as long as the controls connected to the input grid circuit of the tube remain open. When these contacts close, the relay is de-energized. A built-in time-delay feature prevents chattering when the contacts in the input circuit are momentarily closed. A contact arrangement on the electromagnetic relay permits the device to be used either to make or break a load circuit when the actuating contacts connected to the input circuit on the electronic relay are closed. Industrial Control Div., General Electric Co., Schenectady, N. Y.

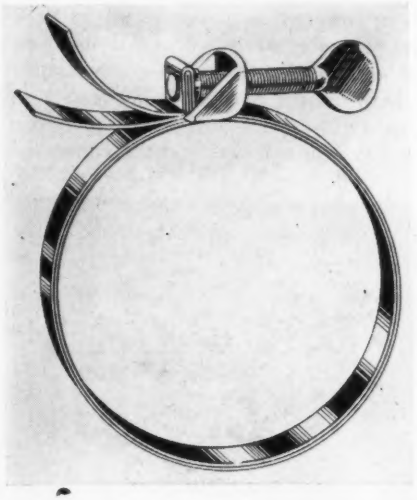
Metal Impregnating Compound

For impregnating and sealing magnesium and aluminum castings No. 988 compound consists of a mixture of a synthetic resin and monomeric styrene. The resin is a 100 percent nonvolatile compound having a viscosity of Y-Z on the Gardner Holdt scale. Usual mixing proportion is equal parts resin and styrene, but may be varied depending on the porosity of the casting. The resin is said to cross-link with the styrene molecule during polymerization without the aid of a catalyst. Because of this cross-linkage the copolymer is insoluble in gasoline. The recommended procedure for sealing porous castings is to remove the air from the casting in a vacuum and force the compound in under pressure. Variations, though, may be made in this technique to meet certain specialized conditions. After impregnation the casting is baked

mer is for use in preparing 24-kt. and alloy solutions. The latter are used in conjunction with 24-kt. gold in preparing alloy plating solutions. Tests based on government specifications show acid resistance up to 3 hr. for a 70-sec. application. Alrose Chemical Co., Providence, R. I.

High-Pressure Hose Clamp

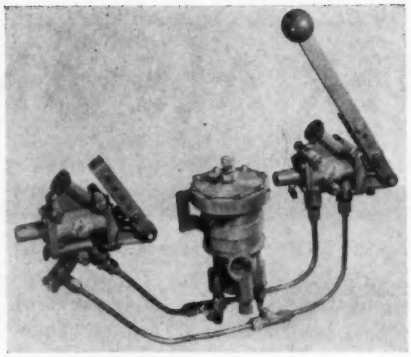
Strength and flexibility are features of a flexible double-strap hose clamp for high-pressure installations. The clamp is so designed that a single length will operate from the maximum possible with respect to circumference down to ⅜ in. dia. In addition, any number of clamps can be connected



end-to-end to surround large diameters. In this case the take-up of the single clamp is multiplied by the number of clamps used. The clamp can be installed after the hose is in place. Actus Products Co., Mt. Vernon, N. Y.

Hydraulic Control

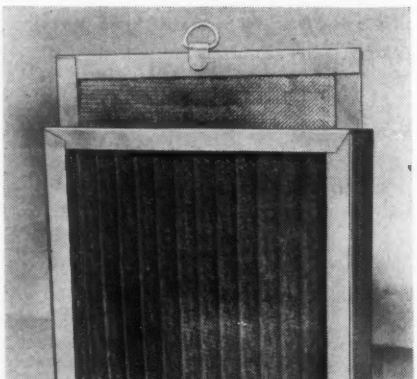
Recent improvements in Isodraulic remote controls include elimination of the diaphragm and auxiliary chamber of the equalizer unit and addition of synchronizing screws bypassing the pistons of the "Master" and "Slave" units, which permit bleeding and filling the system at one point without breaking any connections. This also provides rapid indexing of the lever positions. The two-line hydraulic system provides accurate response at the "Slave" unit to motion in either direction initiated at the "Master." It is now available with or without an integral lock, which in the "Slave" unit of the irreversible system maintains the selected position against load and vibration. Locking system and piston design have been improved to reduce the handle load to



4½ lb. for the irreversible system and 2½ lb. for the reversible system, using an 8-in. lever. The units can be mounted in any position and at varying elevations. Stacking width of "Master" and "Slave" units is 1¼ in. Total weight of the three units is less than 3¼ lb. Adel Precision Products Corp., Burbank, Calif.

Oil Separator Filter

Fire and health hazards from oil thrown into the air can be reduced by the use of Type R-56B oil separator filter. Installed in a ventilating system the filter removes oil entrained in the air, but does not remove oil smoke or liquids in a vapor state. The unit consists of a permanent, viscous impinge-



ment filter and a removeable oil-collecting medium. The filter panel is available in standard sizes. Air-Maze Corp., Cleveland 5, Ohio.

Flexible Insulating Varnish

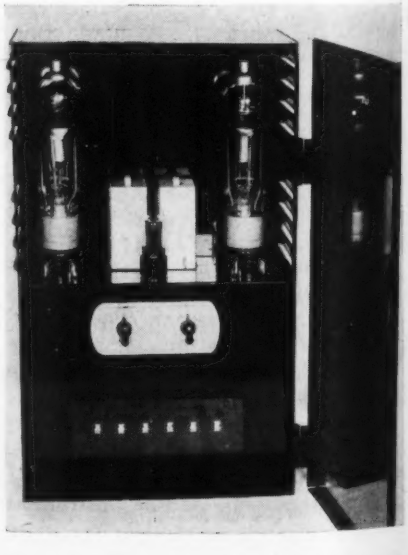
Development of R-851 flexible insulating varnish, designed for applications that demand exceptional lead wire flexibility in addition to high mechanical strength, has been announced. The varnish is also said to be suitable for coating armature and stator coils that will be stored for long periods before assembly. It is a clear baking varnish that dries throughout when baked at 135 deg. C. The varnish is oil, water, acid, and alkali resistant. It is suitable for electrical equipment that is wound with glass-covered wire and designed to operate at high operating temperatures. Sterling Varnish Co., 188 Ohio River Blvd., Haysville, Pa.

Solderless Tube Caps

Designed for heavy-load, high-temperature operation on power tubes, solderless tube-cap terminals are made in various metals for operation in any range of temperature. Hot-electrotinning resists corrosion on all types. Diamond Grip caps are for use on insulated wire where an insulation support type of terminal is required. Standard Type B units can be used on either insulated or non-insulated wire. Each type is available as an individual item or can be ordered as an integral part of a complete lead built to specifications. Aircraft-Marine Products, Inc., 1591R N. Fourth St., Harrisburg, Pa.

Electronic Timers

Two electronic timers, designated Series A and Series B have been announced. The former is especially suited for short-time operations of 45 cycles or less and is accurate in the ½-cycle range. It can also be used as a contactor for loads of ½ kva. or less. When used as a timer to control a large contactor, any amount of power can be controlled through either a mechanical or an electronic-tube contactor. Series B, illustrated, has a control range from ½ to 45 cycles. It is also a contactor for loads up to 15 demand kva. and can be used as a heat control



from 1 to 100 percent in stepless variation. Dimensions are 12x8x4 in. for Series A and 20½x12½x7 in. for Series B. Weights are 10 and 30 lb., respectively. Electronic Products Co., Geneva, Ill.

Rotary Air Motor

For use where explosive or inflammable gases or materials are present, a series of motors operated by compressed air is available in a wide range of speeds and horsepowers. The compressed air used may vary from 1 cu.ft. per min. up

and the pressure from 10 to 100 lb. per sq.in. Horsepower ranges from 0.03 upward, and the speed can vary from 50 to 1,800 r.p.m. The motors are controlled by an air valve and are reversible. Leiman Bros., 128-28 Christie St., Newark, N. J.

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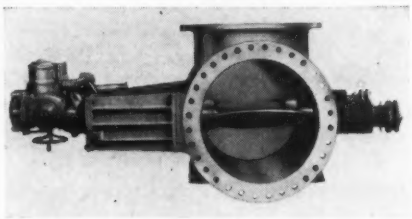

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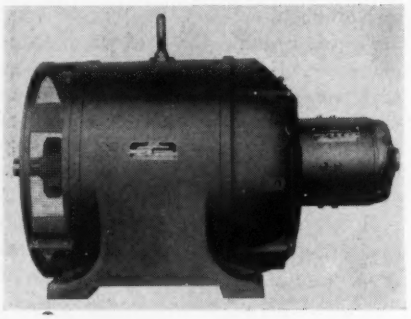
under pressure for two hours at 250–275 deg. F. to polymerize the compound. The usual industrial cleaners are satisfactory for removing the solution from the outside of the casting after impregnating and before baking. Ault & Wiborg Div., Interchemical Corp., 1754 Dana Ave., Cincinnati, Ohio.

A. C. Generator

For direct connection to a gasoline engine or a belted drive an a.c. revolving-field generator has its shaft machined to receive a flange that bolts directly to the engine shaft. The generator has one bearing because the engine end of the shaft is supported by the engine bearing. The exciter is mounted on the end of the generator opposite the engine. The exciter shaft is inserted and keyed to the generator shaft on the in-



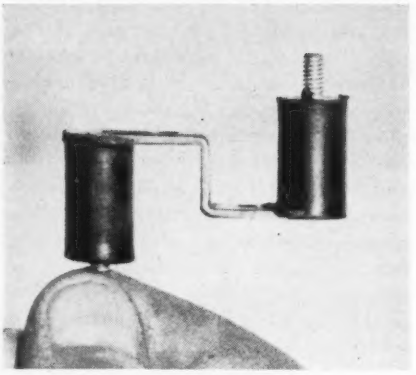
ner end. The generator bearing carries the exciter, which as one bearing on the outer end. Sizes available range from ½ to 150 kva. Century Electric Co., 1806 Pine St., St. Louis, Mo.

Circular Slide Rule

Average accuracy in making rapid calculations with the Monitor circular slide rule is ¼ of 1 percent. The scales are on a 6-in. dia. disk of white Vinylite with black markings. Length of multiplication-division scale is 13.8 in. The front side has log, C, D, and CI scales. The reverse side has sine, tangent, A and D scales. The slide rule resists water and grease and can be cleaned with soap and water. Tavella Sales Co., 27 W. Broadway, New York 7, N. Y.

Resilient Mounting

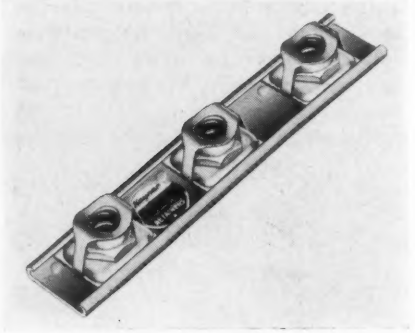
Cylinders of rubber or rubber-like materials interconnected by arms in S-fashion make up a resilient mounting. This arrangement permits a soft suspension under light load and allows freedom of movement in all directions. Shear, bending, torsional or twisting



stresses are handled by the mounting, which also can be stressed simultaneously under both shear and tension. Various arrangements of the rubber cylinders and arms change the rate of deflection in any direction. The degree of movement permitted by the resilient bodies allows action in any direction to be controlled by the way in which the mounting or groups of them are installed. B. F. Goodrich Co., Akron, Ohio.

Gang Channel

Consisting of Click retainer plates and springs made of cadmium-plated tempered spring steel and ST aluminum-alloy channel, Click gang channel



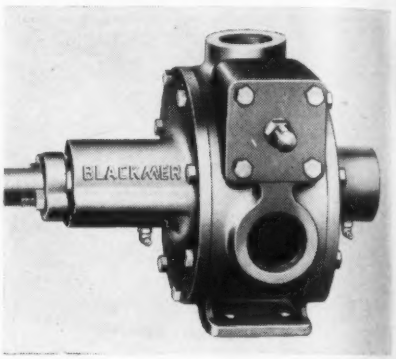
is intended for use in aircraft, marine and ordnance installations. Easy removability using any make of standard hex vibration-resistant nuts or bolts and high torque value are features. The channel is available in all standard sizes, including straight and curved sections. Kayner Mfg. Co., 820 E. 16th St., Los Angeles 21, Calif.

Fungus-Resistant Lacquer

Protection against humidity and fungus growth is provided in Dulac No. 86 lacquer which also features high dielectric strength. The lacquer was developed for communication equipment used in tropical climates. Complying with U. S. Signal Corps Specification #71-2202-A, it is a clear, quick-drying lacquer that may be applied by spraying, brushing or dipping. Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.

Pumping Unit

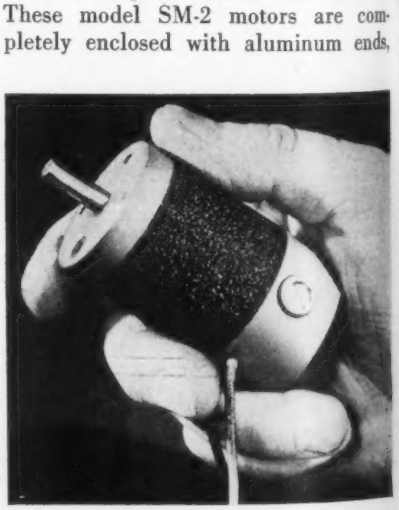
Double bearings arranged one on each side of the rotor reduce shaft whip and distortion in a pump unit for mounting on trucks. The pump incorporates the swinging-vane principle of operation and is designed for standard power take-off. It has a capacity of 35 gal. per min. at 525 r.p.m. Normal operating pressure is 45 lb. per sq. in.



A relief valve built into the pump casing bypasses the capacity of the pump without shock or end-thrust on the working parts, and is free from chatter. Suction and discharge connections are tapped for 1½-in. iron pipe. Blackmer Pump Co., Grand Rapids, Mich.

Fractional Horsepower Motor

For installations requiring maximum power per ounce of weight, such as cooling fans and blowers, vacuum pumps, remote control of radio and instruments, band switching and other airplane applications, Bantam fractional horsepower motors are offered. These model SM-2 motors are completely enclosed with aluminum ends,



ball bearings and stainless steel shafts. They run at speeds from 2,000 to 20,000 r.p.m. on a.c., d.c. or both and are reversible with high starting torque and low current draw. Windings, for 6 to 230 volts, are of high-grade magnet wire, impregnated with varnish. Flange, clamp, base or integral mountings are furnished for operating in any position. Small Motors, Inc., 1308 Elston Ave., Chicago 22, Ill.

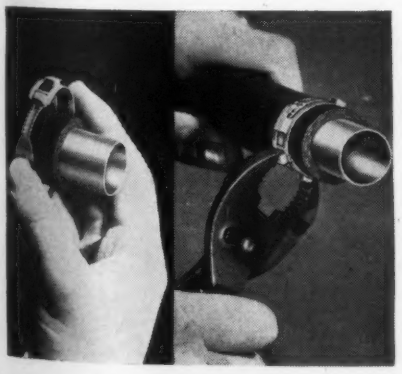
Control Switch

For pressure and temperature control the Ashcroft Duraswitch is offered in combination with the Ashcroft gage. The gage has a slide-rule type dial for accurate adjustment of the switch. This combination saves space, eliminates extra fittings and improves appearance. Series E-100 is for pressure only; Series E-200 is for both pressure and

temperature applications, as a pressure control and thermometer combination, in single or duplex types. Electro-Mechanical Div., Manning, Maxwell & Moore, Bridgeport 2, Conn.

One-Piece Hose Clamp

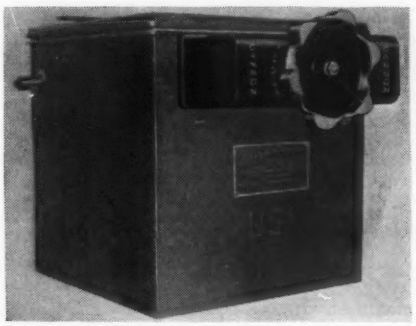
No gears or thumb screws are used in a one-piece hose clamp made of S.A.E. 1060 spring steel with Parkerize or zinc chromate primer finish. The clamp is snapped over the hose in a pre-latched position by hand, as shown at the left in the illustration. Final lock is made with pliers, as shown at right.



It is made for low-pressure connections and has a low profile. Available in all sizes of AN and ordnance specification hose in a wide range from ½ in. O.D. up. Tinnerman Products, Inc., 2041 Fulton Rd., Cleveland 13, Ohio.

Battery Connector

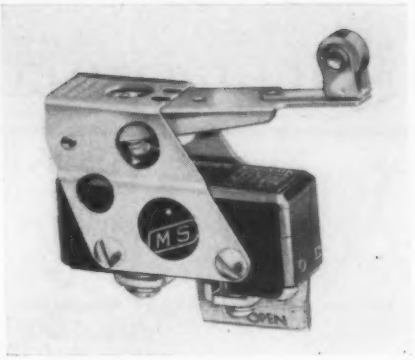
Based on the screw-jack principle, a quick-disconnect battery connector speeds removal of batteries and reduces short-circuit and fire hazards. The handwheel which turns a gear and disengages the battery is notched and can be turned by a gloved hand in sub-zero temperatures. Pin contacts in the re-



ceptacle are so inclosed by the shell that they cannot touch any outside metal surfaces during removal. The receptacle is made of aluminum alloy finished with black acid-resistant lacquer. The two pin contacts are leaded copper for 12-24-volt rating, 600-amp. continuous duty. The plug shell material is molded phenolic, and the handwheel is aluminum alloy with an acid-resistant black-lacquer finish. Cable outlets of ⅝-in. dia. are located on both ends of the connector, but alternate arrangements are possible. Cannon Electric Development Co., 3209 Humboldt St., Los Angeles, 31, Calif.

Adjustable Actuator Bracket

Adjustment of both the operating point and pretravel is the principal feature of an adjustable actuator bracket for Microswitches. Designated AD-5721-R, the bracket retains the sealed-in features of the basic Microswitch which prevent tampering with the control elements but provide tabs on the steel actuator bracket and the lever arm that can be bent to change the mechanical characteristics of the unit. By bending one of the tabs downward the lever mechanism is held nearer to the operating plunger of the Microswitch. The more the tab is bent, the less pretravel there is. The lever arm is returned to the free position after each operation by a pretravel



spring that rests on top of the switch unit. The operating point of the combination is lowered or raised by bending another tab that is part of a steel lever arm and carries the overtravel spring mechanism. This mechanism consists of a spring that is preloaded above the operating point of the Microswitch unit so that it compresses only after the switch operates. The motion of the actuator mechanism is carried by a lever. Micro Switch Corp., Freeport, Ill.

Improved Flow Gage

Advantages incorporated in the redesigned Universal Rotameters for indicating rate of flow of a liquid or gas are improved appearance, greater flexibility of installation and easier maintenance. One-piece frame construction has been retained and new type end-castings allow for 25 different piping hook-ups.

The inside of the tube can be cleaned without removing it and the tube assembly can be withdrawn without disturbing pipe connections. Schutte & Koerting Co., 12th and Thompson Sts., Philadelphia 22, Pa.

Manufacturers' Publications

Tube Fittings—Parker Appliance Co., Cleveland, Ohio. Wall Chart. Parker AN equivalents for AC and NAF fittings are shown and charts covering interchangeability, tube-fitting thread sizes and identification are included.

Bellows—Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill. Bulletin, 40 pages. Principles, construction and engineering advantages of spring-life and other types of bellows made by the company are covered as well as products of the new MetaLastic division.

Chain Belts—Aviation Division, Baldwin-Duckworth Div., Chain Belt Co., 369 Plainfield St., Springfield, Mass. Engineering Handbook No. 67, 24 pages. Design of machine-finished roller chain and its application to aircraft controls, including a section on accessories, are covered.

Couplings — Farrel-Birmingham Co., Ansonia, Conn. Bulletin, 8 pages. Engineering details of Farrel Manger couplings are explained and illustrated with tables of sizes, ratings and dimensions included.

V-Belts—Goodyear Tire & Rubber Co., Akron, Ohio. Pamphlet, 33 pages. Details on care and installation of all types of V-belts are presented in this reprint from the company's "Handbook of Belting."

Copper Plating — United Chromium, Inc., 51 E. 42nd St., New York 17, N. Y. Bulletin, 6 pages. Unichrome alkaline copper plating process is described and a table of plating times for various desired thicknesses is included.

Plating Plastics—Metaplast Co., 205 W. 19th St., New York 11, N. Y. Pamphlet, 16 pages. Covers features, properties and applications of the Metaplast process for plating metal on non-metals.

Switches—General Control Co., 1200 Soldiers Field Rd., Boston 34, Mass. Catalog and Handbook No. 441, 12 pages. Describes in detail three types of foot-, knee- or elbow-operated switches.

Centrifugal Castings—Pettibone Mulliken Corp., 4710 W. Division St., Chicago 51, Ill. Catalog, 12 pages. Typical examples, grain structure and solidification action comparisons and special shapes possible with centrifugal casting are presented along with a clear and concise explanation of the centrifugal-casting process.

Compressors — Worthington Pump & Machinery Corp., Harrison, N. J. Bulletin No. L-667-B1. Features and advantages of Type YC Feather Valve air compressors are described and illustrated.

Beryllium Copper — Riverside Metal Co., Riverside, Burlington County, N. J. Booklet, 12 pages. General information, physical constants, properties, forms available, tolerances and methods of working of beryllium copper are presented.

Springs—Wallace Barnes Co. Div., Associated Spring Corp., Bristol, Conn. Design Charts. Basic data to determine safe load and rate of deflection for helical extension or compression springs are given.

Chain Belts—Chain Belt Co., 1600 W. Bruce St., Milwaukee 4, Wis. Bulletin No. 437, 8 pages. Features chain belts made of Z-metal.

Pipe Couplings—Victaulic Company of America, 30 Rockefeller Plaza, New York 20, N. Y. Catalog and Engineering Manual No. 44, 36 pages. Lists flexible couplings and fittings for use with grooved pipe and presents a guide to their use in several fields.

Hard Rubber—B. F. Goodrich Co., Akron, Ohio. Catalog Section, 4 pages. Distinguishing qualities, applications and suggestions for working of various types of hard rubber for engineering purposes are presented.

Zinc Alloys—New Jersey Zinc Co., 160 Front St., New York 7, N. Y. Presents technical data on zinc alloys for die-casting based on knowledge and experience gained from recent developments in die-casting equipment, die design and die-casting art.

Fastener—Tinnerman Products, Inc., 2038 Fulton Rd., Cleveland, Ohio. Folder, 3 pages. Gives dimensional data and mounting instructions for Speed Nut A6939 for front mounting of aircraft instruments.

Stainless Steels—Carpenter Steel Co., Reading, Pa. Chart. Lists stainless steel type numbers and describes eleven tests to help in quick identification of these alloy steels.

Aluminum Alloys—National Smelting Co., 6700 Grant Ave., Cleveland 5, Ohio. Booklet, 16 pages. Properties and characteristics of Red-X aluminum alloys are covered.

Vinyl Resins — Chemical Div., B. F. Goodrich Co., Akron, Ohio. Folder, 4 pages. Properties and characteristics of Geon vinyl resins and plastics are discussed.

Surface Roughness—Dept. 7, Physicists Research Co., 343 S. Main St., Ann Arbor, Mich. Booklet, 12 pages. Information on surface roughness and its measurement is contained and the line of Profilometer roughness-gaging equipment is described.

Valves, Pipe and Fittings—Crane Co., 836 S. Michigan Ave., Chicago 5, Ill. Booklet, 32 pages. Valve designs and types of pipe fittings make up a large part of this general presentation on piping.

Combustion Control—Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. Catalog N-01M-163, 36 pages. Features several recent installations of Metermax combustion control and describes engineering features.

Synthetic Rubber—Chemical Products Dept., Stanco Distributors, Inc., 26 Broadway, New York 4, N. Y. Supplement No. 2, 9 pages. Presents suggested Perbunan synthetic rubber formulations for some applications of the revised S.A.E. Aeronautical Material Specifications.

Engine Controls—Synchro-Start Products, Inc., 221 E. Cullerton St., Chicago 16, Ill. Catalog, 48 pages. Describes and illustrates various automatic and semi-automatic controls used on internal combustion engines.

Bi-Metal—Callite Tungsten Corp., 540 39th St., Union City, N. J. Bulletin No. 155, 4 pages. Technical data for design engineers on the deflection and power of various types of bi-metal in strip and coil. Thicknesses and sizes are given.

Hose Couplings — Eastman Mfg. Co., Manitowoc, Wis. Catalog No. 43-Hydraulic, 20 pages. Couplings for various assemblies of hydraulic hose lines are listed and illustrated.

Volumes of Spherical Segments

C. P. NACHOD
Nachod & United States Signal Co., Inc.

THIS nomogram is designed for calculating graphically the volume of a spherical segment such as would be used for the rounded ends of tanks.

The chart is based on the equation

$$V = \pi h^2 \left(r - \frac{h}{3}\right) = \pi h^2 \left(\frac{d}{2} - \frac{h}{3}\right)$$

in which

V = volume of the segment
h = height of segment
r = radius of sphere
d = diameter of sphere

The nomogram gives h up to a hemisphere for d up to 10. For a greater range of values, the volume of the spherical segment can be found by proportion since the volumes of similar segments are proportional to the cubes of their diameters. For example, let the diameter d of the sphere equal 15 in. and h equal 6 in., V' can be found as follows:

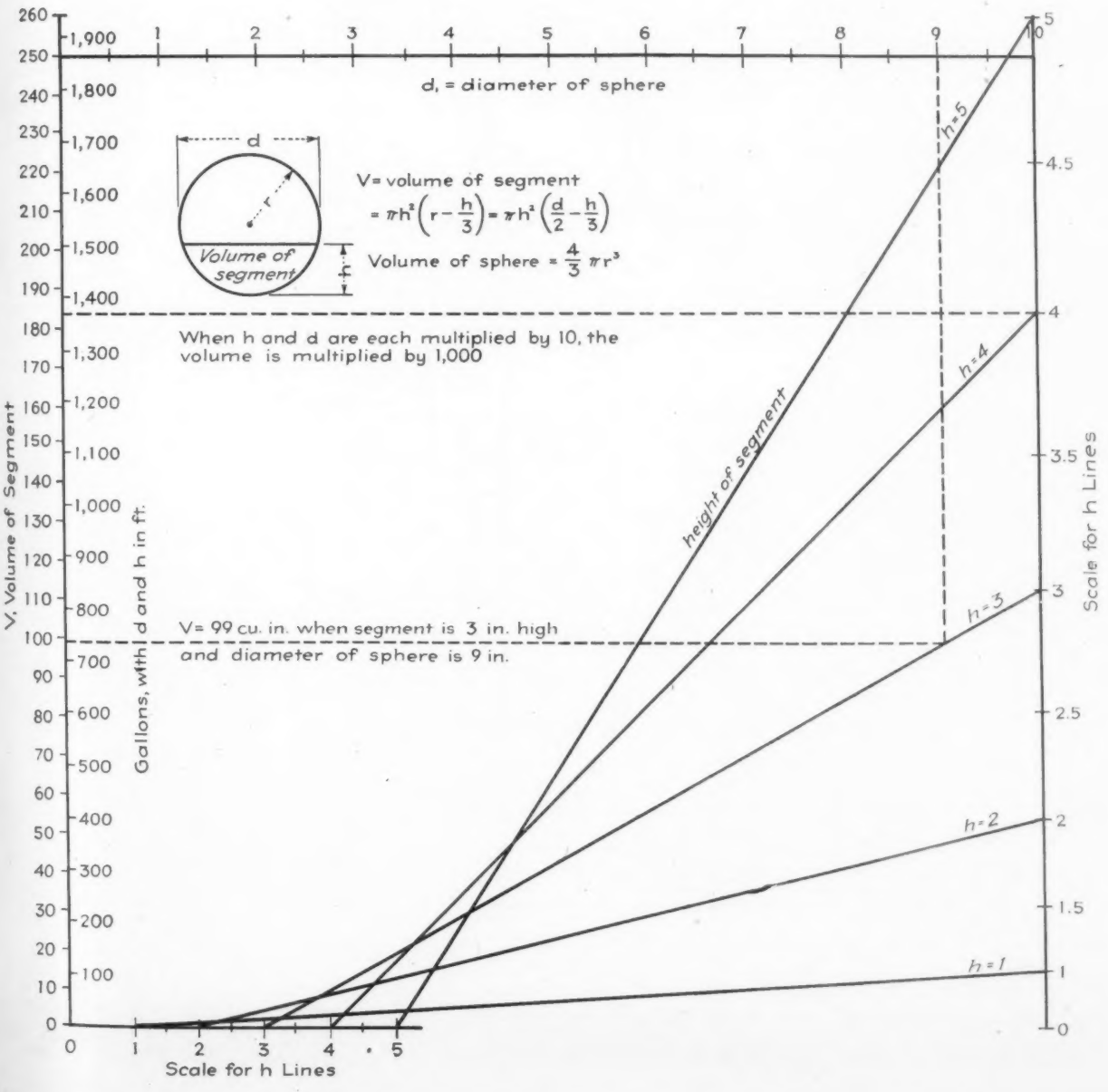
$$\frac{h}{d} = \frac{6}{15} = \frac{4}{10}$$

Chart shows for d equal to 10, and h equal to 4, that V equals 184 cu. in.

Then for d equal to 15, and h equal to 6

$$V' = \left(\frac{15}{10}\right)^3 \times 184 = 1.5^3 \times 184 = 621 \text{ cu. in.}$$

Scales are shown for drawing more h lines so that the precise one needed for any calculation can be drawn.


d, = diameter of sphere
d
r
Volume of segment
V= volume of segment
= πh²(r − h/3) = πh²(d/2 − h/3)
Volume of sphere = 4/3 πr³
When h and d are each multiplied by 10, the volume is multiplied by 1,000
V= 99 cu. in. when segment is 3 in. high and diameter of sphere is 9 in.
height of segment
h=5
h=4
h=3
h=2
h=1
V, Volume of Segment
Gallons, with d and h in ft.
Scale for h Lines
Scale for h Lines

Lamp Dimming Rheostat Chart

FROM Lamp Data Chart ascertain current for each type of lamp required, both at 4.2 volts and 28 volts. Multiply these by number of lamps of each type on circuit. Add total currents for each lamp type at 4.2 volts and 28 volts to obtain maximum and dim values of total current. Then refer to chart to find proper dimming rheostat.

EXAMPLE 1. Three T3 ¼ lamps in parallel.

Lamp Data Chart gives for each lamp

at 4.2 volts, amp. = 0.055

at 28 volts, amp. = 0.175

Dim value of total current = 3 × 0.055 = 0.165 amp.

Maximum total current = 3 × 0.175 = 0.525 amp.

Intersection of ordinate for 0.165 amp. at 4.2 volts and abscissa for 0.525 amp. at 28 volts occurs in box No. 10. From Rheostat Data Table, No. 10 rheostat is 150 ohms with a capacity of 50 watts.

EXAMPLE 2. Seven T3 ¼ and eight G3 ½ lamps connected in parallel.

Dim value of total current for seven T3 ¼ lamps at 4.2 volts.

7 × 0.055 = 0.385 amp.

Maximum total current for seven T3 ¼ lamps at 28 volts

7 × 0.175 = 1.225 amp.

Dim value of total current for eight G3 ½ lamps at 4.2 volts.

8 × 0.074 = 0.592 amp.

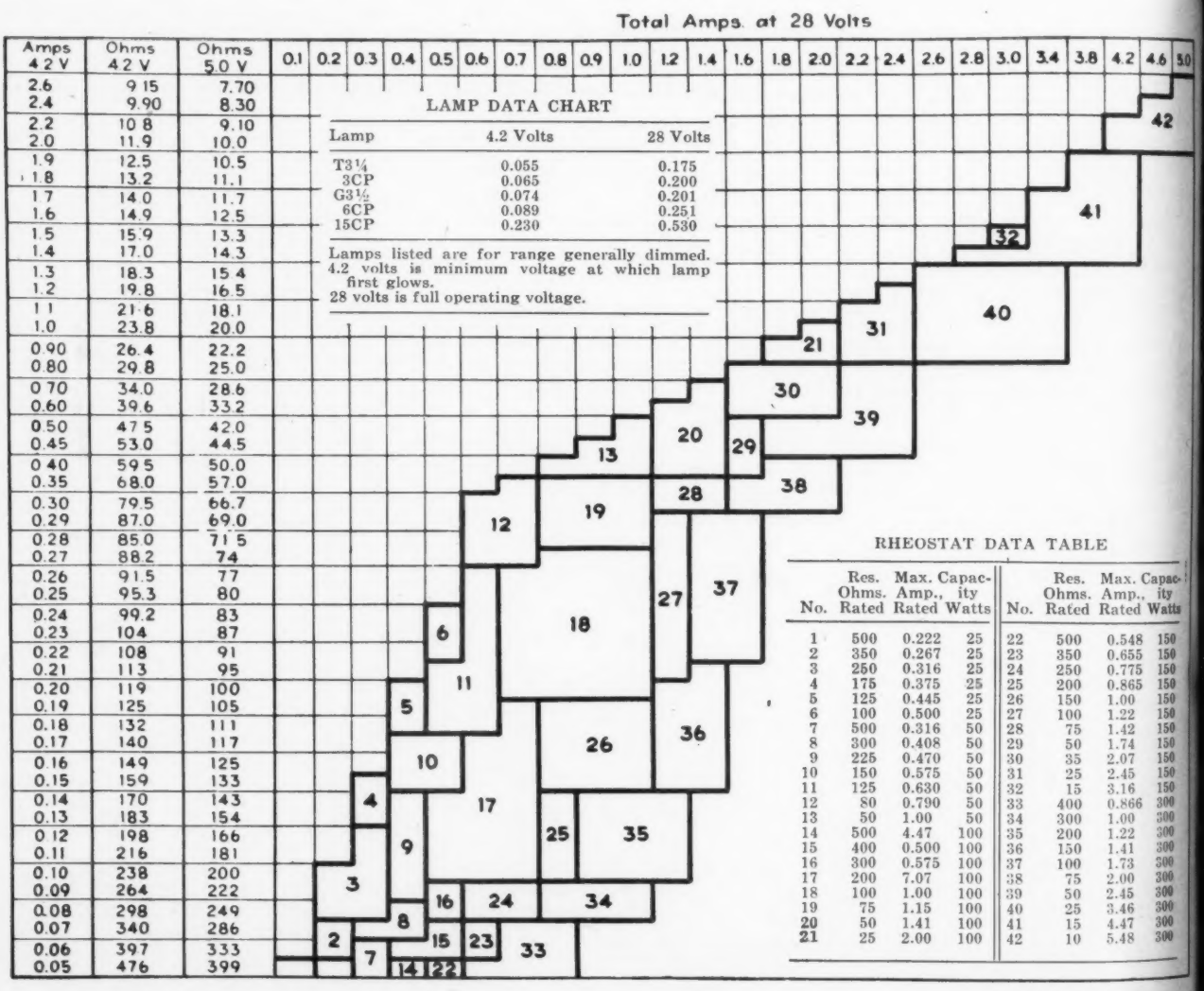
Maximum total current for eight G3 ½ lamps at 28 volts

8 × 0.201 = 1.608 amp.

Total amp. at 4.2 volts = 0.385 + 0.592 = 0.977

Total amp. at 28 volts = 1.225 + 1.608 = 2.833

Intersection of ordinate and abscissa on chart occurs in Box No. 40. From Rheostat Data Table, No. 40 rheostat is 25 ohms with a capacity of 300 watts.



RHEOSTAT DATA TABLE

No.	Res. Ohms. Rated	Max. Amp., Rated	Capacity Watts	No.	Res. Ohms. Rated	Max. Amp., Rated	Capacity Watts
1	500	0.222	25	22	500	0.548	150
2	350	0.267	25	23	350	0.655	150
3	250	0.316	25	24	250	0.775	150
4	175	0.375	25	25	200	0.865	150
5	125	0.445	25	26	150	1.00	150
6	100	0.500	25	27	100	1.22	150
7	500	0.316	50	28	75	1.42	150
8	300	0.408	50	29	50	1.74	150
9	225	0.470	50	30	35	2.07	150
10	150	0.575	50	31	25	2.45	150
11	125	0.630	50	32	15	3.16	150
12	80	0.790	50	33	400	0.866	300
13	50	1.00	50	34	300	1.00	300
14	500	4.47	100	35	200	1.22	300
15	400	0.500	100	36	150	1.41	300
16	300	0.575	100	37	100	1.73	300
17	200	7.07	100	38	75	2.00	300
18	100	1.00	100	39	50	2.45	300
19	75	1.15	100	40	25	3.46	300
20	50	1.41	100	41	15	4.47	300
21	25	2.00	100	42	10	5.48	300

Lockheed Aircraft Corporation

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